Should We Teach Mathematics to Young Children?

An Awareness of Toddlers' Mathematical Learning Through Pedagogical Documentation

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Research with infants has demonstrated their ability to recognize and discriminate among small numbers of objects (Clements and Sarama 2009; Cross et al 2009; Varol and Farran 2006). Other studies have revealed the use of complex and sophisticated mathematical ideas emerging in children's play and everyday moments (Clements and Sarama 2009; Ginsburg, nd). These everyday experiences are the beginning of young children's interest in and understanding of the world from a mathematical perspective. However, this capability and the resulting opportunities for young children to learn and become competent in mathematics are, for the most part, not currently recognized or achieved in many early childhood and child care settings. How, then, can I bring an awareness of early mathematics to my work in child care with infants and toddlers? In this paper I will describe how, through the use of pedagogical documentation, I gained insight into children's mathematical learning.

Pedagogical Documentation Project

> Pedagogical documentation ... is mainly about trying to see and understand what is going on in the pedagogical work and what the child is capable of without any predetermined framework of expectations and norms. (Grieshaber and Hatch 2003, 90)
>
> It is through pedagogical documentation that learning processes can be shared, discussed, reflected upon and interpreted—not only by educators, but also by children, parents, and anyone wishing to gain deeper understanding. (Rinaldi 2005, 17)

From two rounds of investigation and using a pedagogical documentation inquiry process of framing and reframing questions, planning a starting point for the investigation, collecting data and analyzing data (Gandini and Goldhaber 2001), I endeavoured to learn about our toddler children's mathematical learning in their play. For two mornings I worked as part of a team with two other early childhood educators. Through deliberate and careful selection of data (pictures, my interpretations, educational quotes and teacher–child dialogue) that gave us insights into the children's sense making and mathematical learning, we developed a documentation panel and displayed it in the common area of our centre for families, visitors, staff and children to view. Documentation in this form allows children's learning to be made visible and brings together the educator's reflective interpretations on children's developing theories—what the children know and what they are learning. A teacher engaged in pedagogical documentation shifts from teaching children to studying and learning with the children. What follows is my learning story, a pedagogical documentation of what took place over two days of engaging in learning activities with a group of toddlers.

My inquiry began with an understanding, gained through research and literature, that children's play and interests are often the source of children's first mathematical experiences and that "these experiences become mathematical as the children represent and reflect on them" (Clements 2001b, 272). This understanding also implied that early mathematics is more than getting children ready for school or accelerating them toward elementary school math. "Appropriate mathematical experiences challenge young children to explore ideas related to patterns, shapes, numbers, and space with increasing sophistication" (*Early Childhood Today* editorial staff 2002, 1). Therefore, the beginning questions to my investigation were (1) where do we see mathematical learning in the children's play? and (2) how do our toddlers experience and make meaning of mathematical concepts in their play? Inspired by the following words from an interview of Clements (Clements 2001a), I began observing and engaging with a group of seven toddlers.

> When it comes to developing mathematical skills, the younger the children are the less we need to interfere. There's nothing to lose and everything to gain by putting on your "math glasses" as you watch children involved in activities all around the room. Try to understand what is really going on and then ask questions or offer objects that will help children see the math behind the activity. (p 6)

Day One of the Inquiry

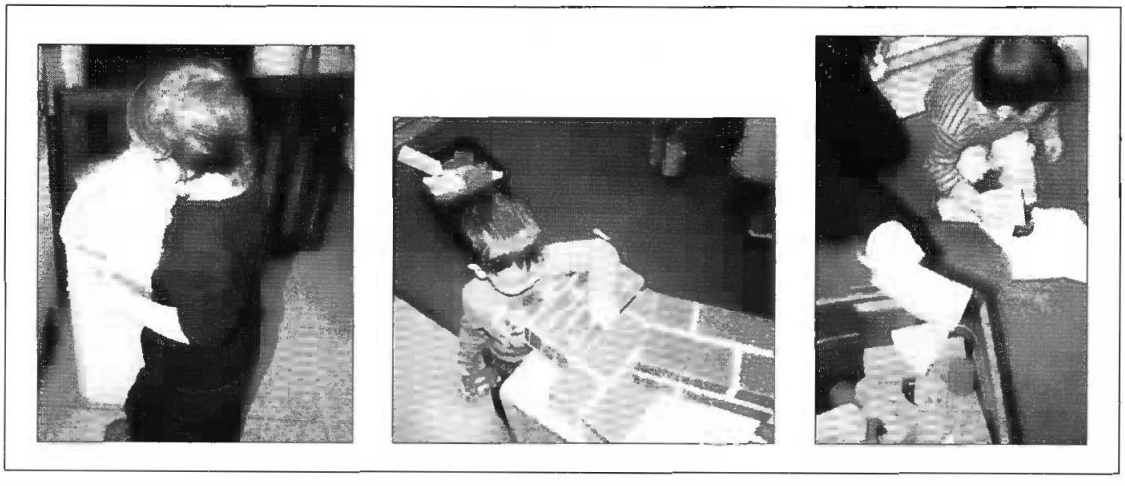
With this inspiration to see through "math glasses," it was illuminating (perhaps even surprising) to see the abundance of mathematical content and learning experiences that became visible in our toddler children's play, daily activities, and child–teacher communications. Mathematical words and language appeared in meaningful context in many routine care activities, transition times and play experiences. For example, the early childhood educators modelled and extended math concepts in language communications at breakfast time—the math concept of one-to-one correspondence was observed in teacher verbalizations such as "One piece of toast for you, one for you and one for you." Similarly, the children's simple verbal communications demonstrated their developing understanding of the concept of addition by saying simply "More" to request or acknowledge another piece of toast or glass of milk (Clements and Sarama 2009). Transition and cleanup times also contained critical learning experiences and language of concepts of spatial reasoning, comparison and classification when the teacher said, for example, "Go put your facecloth in the laundry bucket," "Let's put the little blocks in the box and the big blocks on the shelf" (see Figure 1).

> Many types of language are vital for mathematics learning. One is simple mathematical vocabulary. The words *more* and *another* are among the first that toddlers learn. Indeed, young children's early language comprises many words that refer to quantity, shape, location, and the like, such as *one*, *only one*, *the most*, *round*, *straight*, *in front of*, *behind*, *underneath*, *big*, *bigger* and *biggest*. Now you do not usually think of these words as mathematical, but they are: they refer to fundamental concepts that mathematics formalizes and clarifies. (Ginsburg 2009, 409)

Clements and Sarama's Learning Trajectories Approach to mathematics (2009) is frequently recommended for teachers of children under the age of three to provide rich sensory and manipulative environments as the instructional focus. Therefore, activities that were purposely made available for the toddlers on day one of our investigations were block play, manipulative-type toys (stacking cups, wire bead mazes) and sand play. Music, songs and stories that included both actions and repetitive words were also planned activities. Along with two other early childhood educators, I observed and was actively engaged in the children's play to appropriately draw attention to and extend their experiential learning of mathematical concepts and language. I had learned to recognize and enhance early mathematics learning in a graduate class on children's mathematical learning, and I passed this on to my team. Our goal was to see the children's everyday play through a new mathematical lens and to enrich and extend that learning.

During free play time, a 25-month-old boy was solely engrossed in play with blocks (see Figure 2). He began by gathering his blocks and stacking one

Figure 1. Spatial, comparison and classification mathematics language in everyday activities



block on top of another. When his block tower reached just the right height he greatly enjoyed pushing the tower over and watching all the blocks tumble to the floor. The teacher said, "You really like watching your tall tower fall!" After observing this child's play for some time, the teacher offered an extension to this boy's play by asking, "What would your tower look like if you started with two blocks?" The teacher modelled the two-block tower and the boy imitated it.

What do we know about children's play with blocks and what have we learned from this child's experience? Clements and Sarama (2005) offer us some insight into children's block play:

> Infants show little interest in stacking. Stacking begins at one year, when infants show their understanding of the spatial relationship *on*. The *next-to* relationship develops at about 1½ years. At two years, children place each successive block on or next to the one previously placed. They appear to recognize that blocks do not fall when placed this way. Children begin to reflect and anticipate. (p 8)

Documenting this boy's play provided us with insights into his developing spatial skills, his understanding of how shapes combine and his knowledge of height and quantity (Clements and Sarama 2009). He also illustrated an understanding of relationships as he demonstrated that he knew how to stack his blocks to build a tall tower without it falling over. He also had an understanding of predicting outcomes, because he knew what would happen with just one push of a block on his tall tower. This boy's play demonstrated that "the benefits of block building are deep and broad" and that "children increase their math, science, and general reasoning abilities when building with blocks" (Clements and Sarama 2005, 7). In this play situation, the teacher understood and recognized the mathematical learning embedded in this child's play and was able to offer both mathematical language and an extension to the learning experience.

After morning free play, the sand table was made available to the children (see Figure 3). Shovels, spoons, small and large buckets, and ice cubes were added to the sand table to enrich and extend the children's play experiences. The teacher gave exploratory prompts and questions such as "Can you fill the large bucket with sand? How many small cups will fill the big bucket?" to draw the children's attention and play toward particular math concepts. Sand play offers many opportunities for exploring mathematical thinking, reasoning and concepts (Clements and Sarama 2005). The concept of measurement underlies the play—we observed the children filling a larger container using smaller cups or shovels over and over again. "Heavy," said a 22-month-old boy as he lifted a large buck filled with sand. "That's right," said the teacher. "Your big bucket filled with wet sand is heavy."

Following sand play was circle time, during which the teachers and children engaged in singing and acting out this song (see Figure 4):

> If your name is *Child's name*, *Child's name*, *Child's name*,
> If your name is *Child's name*, stand up now.
> Jump inside the circle, the circle, the circle,
> Jump inside the circle
> Then sit down.

Figure 2. Spatial thinking and reasoning in block play

The children listened with anticipation and, with their ability to predict, they knew that when their name was called it was their turn to stand up, jump inside the circle and then sit down. This simple action song contains both a repetitive rhythm and an action sequence, and thereby gives the children an early introduction to the mathematical concept of patterning. In order to achieve the action pattern the children were required to listen, recognize the relationship (Geist 2009), and repeat the pattern of standing up, jumping and sitting down.

Day Two of the Inquiry

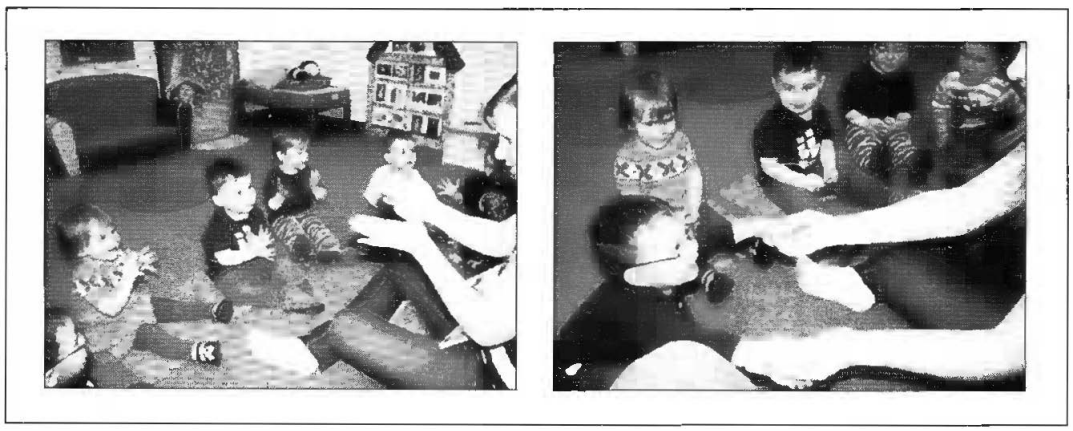
> In any good math activity if you change the "variable" you change and expand the experience as well as the understanding" (Church 2001, 8).
> Play does not guarantee mathematical development, but it offers rich possibilities. Significant benefits are more likely when teachers follow up by engaging children in reflecting on and representing the mathematical ideas that have emerged in their play. Teachers enhance children's mathematics learning when they ask questions that provoke clarifications, extensions, and development of new understandings. (Clements and Sarama 2005, 6)

With this understanding in mind and reflection on the first day of inquiry, the second day of investigations began. Questions leading this inquiry and observations were (1) what new play experiences can be provided to enrich and extend the children's mathematical learning? and (2) what math language can be taught to the children as they play?

On this morning, the teacher placed foam blocks on the playroom floor. The teacher sparked interest in this play by saying to the children "Look at all the different kinds of blocks and shapes we have today." During play with these foam blocks, the older children

Figure 3. Measurement in sand play

Figure 4. Early patterning experiences in music activities



quickly figured out how the rod-shaped tubes fit perfectly into the centre holes of the square foam blocks and the game became putting in and taking out these tubes. "Stuck," said a 22-month-old boy as he passed his square block to the teacher for help in removing the stuck tube. Two of the youngest children in the group (both 19 months old) began their play by merely watching (but with interested curiosity) their friends play the in–out tube game. The teacher recognized this and said to these two young toddlers, "Here is a square block and tube for each of you." Each toddler appeared to know what the other was doing and each tried to fit his tube into the circular hole. It took a few trials and errors, but after a little time both children successfully fit their tubes into the hole (see Figure 5).

By their documentation of this activity the teachers recognized and understood the meaning making of the children's in-–out tube game. The children showed an incipient understanding of combining two parts (tube and block) to make a whole, which is an important early mathematics concept that is related to a later-developing concept of number composition (Clements and Sarama 2009).

Water play was the next activity that the teachers planned with the intention of having the children revisit the concept of measurement they had explored previously with sand. The teacher once again provided exploratory prompts and questions to draw the children's play and attention to particular math concepts in the water play: "Use your small cups to fill the big bucket with water," and "Here is a big bucket to fill with water" (see Figure 6).

Geist (2009) offers us insight into the children's meaning making during water play:

> Toddlers are still constructing the concept that simply changing the shape or arrangement of one or more objects does not change the quantity. This

Figure 5. Part-whole understanding with foam tube and block

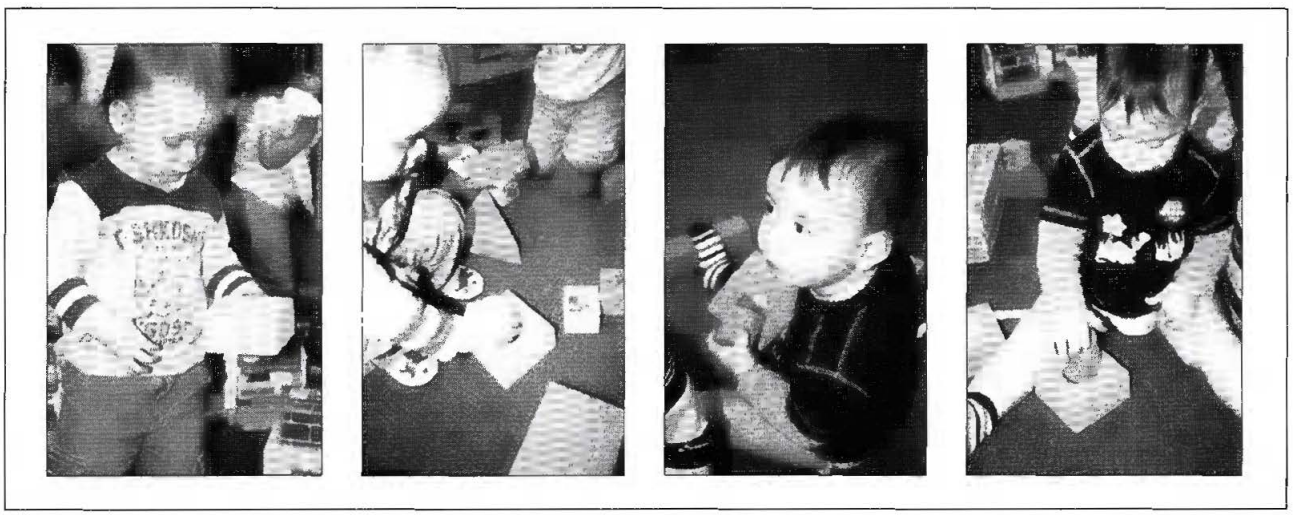
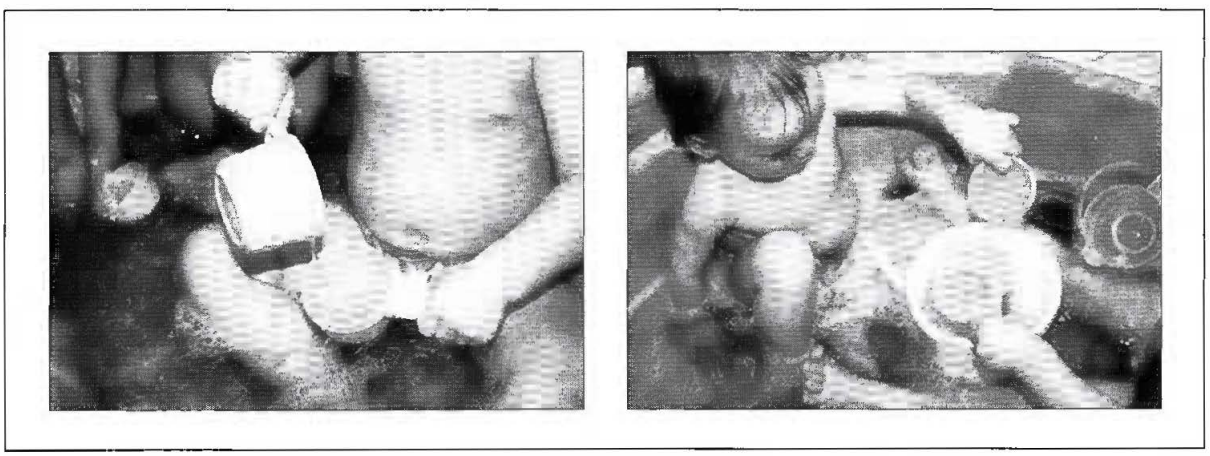


Figure 6. Measurement in water play



> understanding is known as *conservation*, and it will usually not begin to emerge until about age 4. However, this comprehension does not just pop into a child's head—it is constructed slowly, over time, as children play and interact with objects, containers, and substances such as sand and water. Conservation is important to future mathematical content areas, such as classification, seriation and number. (p 41)

Following water play it was time for gross motor play, in which we were going to move and explore the spatial concepts of *up, down, through, over* and *under*.

> Toddlers use their whole body to explore and learn. Being in different positions lets children pay attention to where things and spaces are in relation to one another. Physical activities introduce special relationships and set the stage for understanding geometry and numbers. (Geist 2009, 41)

We were intrigued to discover in this gross motor play the spatial concepts the children already understood and the spatial language they had. The teacher led a discovery walk through the playroom, which had been arranged with all shapes and sizes of climbing blocks. "Follow me," said the teacher. "Let's go on a discovery. We are going up—we are going down—we are going over—we are going under." The children watched the teacher moving through the path of climbing blocks and began their own exploration, talking as they moved. This activity provided surprising evidence that our young toddlers already possessed considerable knowledge and language of spatial concepts. The children moved up, down, over and through the play blocks and chanted, in a very natural way, "Up, down, up, down" as they explored and played. Even the younger toddlers who had not yet developed spoken language knew and could execute quite easily the spatial understanding of *over, through, up*, and *down* (see Figure 7).

Conclusion

Evidence from this pedagogical work illustrates that early mathematics learning can be developmentally appropriate, achievable and enriching for children under the age of three years. Readiness for mathematics is now understood by the educators in my centre not as a question of age-appropriateness but as a way to give children ample and enriching opportunities to explore and think about their world in mathematical ways (Clements and Sarama 2009). However, educators need knowledge about early mathematics content and learning, and they need the intentionality to teach, explore and support early math experiences. The process of pedagogical documentation was a means for educators to question, analyze, reflect, understand and share children's mathematical abilities.

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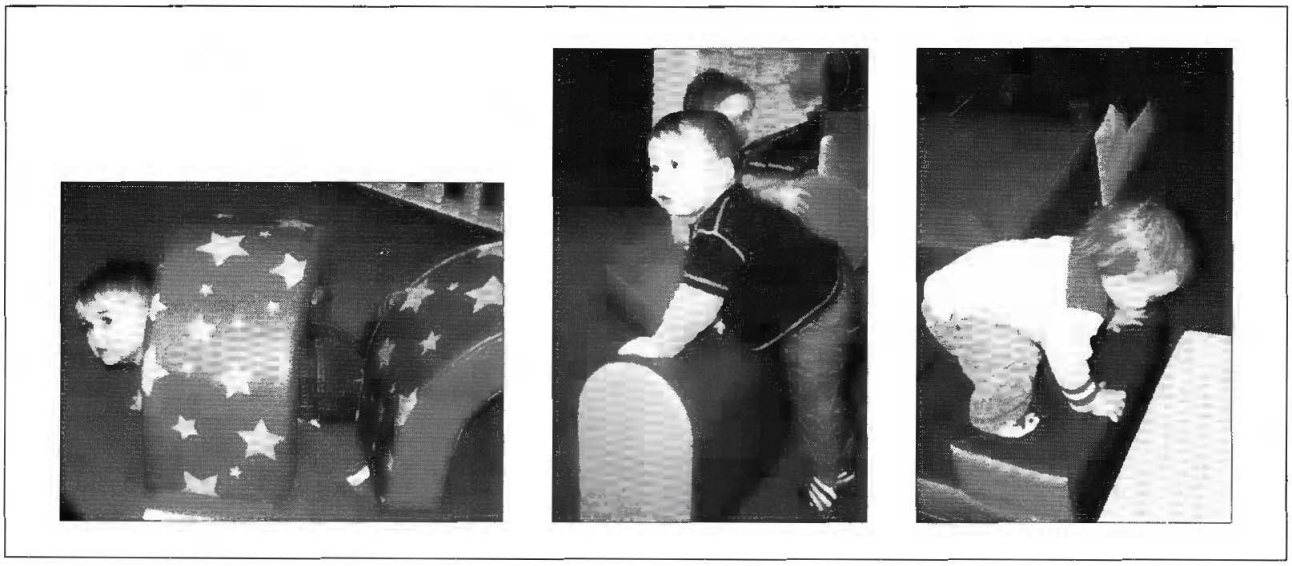
Figure 7. Spatial mathematics of *through, over, up* and *down* in toddler play



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