1) Title: Early Childhood Teacher Education: The Case of Geometry

Source:
Clements, D.H., & Sarama, J. (2011). Early childhood teacher education: The case of geometry. *Journal of Math Teacher Education, 14,* 133-148

Summary:
Geometry is essential as both a math content area and as a focal point for teacher professional development. The authors argue that although geometry underlies all aspects of math (since mathematical ideas are inherently spatial) and other disciplines such as the sciences, it is neglected in early childhood education and in the professional development of early childhood teachers. Most elementary school math teachers admit to having a lack of knowledge of geometric concepts and to the scarcity of professional development opportunities in this area and math in general. The authors introduce a professional development program known as the Building Blocks/TRIAD Model that serves to enrich teachers' content knowledge of geometry along with their understanding of children's learning trajectories in this area. Specifically, teachers build common content knowledge, clarify misconceptions about geometric concepts and explore best practices for teaching geometry. They also examine children's mathematical thinking, and design lessons to advance children's geometric understanding.

2) Title: Spatial Language During Block Play

Authors: Katrina Ferrara, Kathy Hirsh-Pasek, Nora S. Newcombe, Roberta Michnick Golinkoff, andWendy Shallcross Lam

Summary:
Spatial language that occurs during block play can enrich children's understanding of spatial relationships between objects and enhance their spatial reasoning ability. Specifically, spatial language is categorized to include terms for a) spatial locations such as 'up' and 'down', and b) dimensions such as 'long', 'tall', etc. Other aspects of spatial language are discussed in the article. The investigators examined both parents' and children's use of spatial language in three different conditions: 1) free play with blocks, 2) guided play with blocks, and 3) preassembled play with blocks. Results indicated that both parents and children used the most spatial language when engaging in guided play compared to the other two conditions and a fourth play scenario that does not include blocks.

3) Title: Picture this: Increasing Math and Science Learning by Improving Spatial Thinking

Source: Newcombe, N.S. (2010). Picture this: Increase math and science learning by improving spatial thinking. *American Educator, 29-43.*

Summary:
Strong spatial thinking ability has been demonstrated by research to be essential for pursuing careers in sciences, technology, engineering, and mathematics. Spatial thinking generally involves the location of objects and our ability to manipulate them in different ways. It also includes our capacity to relate to and navigate the wider world around us. The article further provides specific examples of spatial thinking questions used for academic assessment. The ability to think spatially is not immutable and can be improved through effective school programming starting from the early years. A list of suggestions and strategies are provided to help teachers enhance students' spatial thinking in the classroom. For example, early years teachers are encouraged to introduce spatially challenging books, teach spatial words, and to introduce students to both standard and non-standard geometric shapes. Gestures are also emphasized to play a key role in helping students improve their ability to think spatially. Thus, teachers should encourage young children to gesture when explaining how they have located or manipulated certain objects. Finally, the author also touches on sex differences in spatial thinking by noting that although they do exist, they do not reflect individual performance. Both boys and girls can become better at spatial thinking through high quality programming.

4) Title: Teaching with Blocks

Source:
Taylor-Cox, J. (2009). Teaching with blocks. *Teaching Children Mathematics, NCTM.*

Summary:
Blocks are powerful mathematical tools that can be used to teach an array of math concepts in the early years. These include: early geometry, algebra, measurement, number sense, computation, and data analysis. In particular, this article focuses on how blocks can enrich math learning in algebra, measurement, and geometry.

<u>Algebra:</u>
- Blocks can be used to create REPEATING PATTERNS that repeat according to colour, size, and/or position

- Blocks can also be used to make GROWING PATTERNS and these are typically described by children to be stairs or steps in a structure
- Blocks can be used to explore BALANCE and EQUALITY
- SORTING blocks is an important mathematical activity
- As children group and classify blocks, teachers should engage them in mathematical talk to make their sorting strategies explicit

Measurement:
- As children order and compare sizes of blocks, they come to understand relative sizes
- Teacher questioning during block play can help children explore concepts such as relative size, weight, and capacity
- Children can also learn about nonstandard units by using different kinds of blocks to measure varying lengths
- Using blocks as nonstandard units helps students practice one-to-one correspondence, number sense, and cardinality

Geometry:
- Through block play, children learn to recognize, build, sort, and compare two- and three-dimensional shapes
- To explore concepts such as position and order, children can be asked to describe the structure they are building by using math vocabulary describing spatial relationships
- Concepts such as area and perimeter (also part of measurement) can be explored through block play

5) Title: Cognitive Correlates of Math Skills in Third-Grade Students

Source: Mannamaa, M., Kikas, E., Peets, K., & Palu, A. (2012). Cognitive correlates of math skills in third-grade students. *Educational Psychology, 32,* 21-44.

Summary:
In this article, the researchers demonstrated the roles that different cognitive abilities play in mathematics learning. Specifically, the researchers looked at how nine different cognitive factors (e.g., non-verbal and verbal reasoning, visuo-spatial working memory, verbal working memory, etc.) are related to four mathematical processes (knowing-recalling, knowing-computing, applying, and problem-solving). They administered a battery of mathematics and cognitive measures to 723 third grade participants in 28 Estonian elementary schools. The researchers found that verbal reasoning and verbal concepts plays a role in mathematics problem solving. Furthermore, simultaneous information processing (a domain of verbal working memory) facilitates children's

ability to solve problems involving complex mathematical reasoning. Its counterpart, successive information processing, facilitates the completion of simple arithmetic problems. These findings show that cognitive factors that underlie verbal abilities also play a significant role in mathematics learning.

Why this article was important for us:

For our team exploration, what stood out from this article are the roles that simultaneous and successive information processing play in children's mathematics reasoning. These two types of information processing are defined as the following:

Simultaneous Information Processing: integration of stimuli into gestalt or spatial groups

Successive Information Processing: integration of stimuli into temporally or serially organized information

We have been investigating children's spatial reasoning. Through our exploratory activities where children had to manipulate shapes to make figures, clear examples of both types of information processing manifested. There were some children who built while visualizing a gestalt and would manipulate the shapes so that they would fit the spatial groupings they had visualized. Other children built their figures one shape at a time until they decided the figure was complete. They may or may not have seen a gestalt, but if they did, they would happen upon it after completion of the figure.

6) Title: Developing Geometric Thinking through Activities that Begin with Play

Source: van Hiele, P. (1999). Developing geometric thinking through activities that begin with play. *NCTM*.

School-taught geometry has often focused on Euclidean principles that assume students can engage in formal deductive thinking. Most do not have this understanding and struggle with the topic. The author argues that the teaching of geometry should fit the students' developmental level and at a young age, this should start with playful activities. The author outlines the different levels of geometric thinking and suggests a sequence of instruction teachers can use to engage in the children. He emphasizes that playful activities and games should be used to foster

understanding of geometry and provides a detailed example using a mosaic puzzle.