Background

How did we get started?
We were asked if we wanted to participate in some math research. We are all teachers from the same school who have worked to build a team approach where we share ideas with a common goal of improving our students' understanding of mathematics. Our team decided this was a meaningful professional development opportunity to improve our teaching practice and understanding of how children learn math. This journey began in January where we set goals and began our explorations together.

Why did we choose this content area?
As a beginning exercise we each reflected on which strands of math we felt we spent the most time on and had the most PD on. We found out that every one of us selected Number and Patterns as the two strands we spend the most time on, and Geometry was at or near the bottom of the list. This made us think that Geometry might be a good focus. We read the literature review on Math for Young Children and this got us excited about what young children can do, and helped us reconsider the role of play and exploration in math. We learned that the consensus in the literature is that "play does not guarantee mathematical development but it offers rich possibilities" (NAYCM/NCTM, 2002). Students who come from underprivileged circumstances come to school with limited experiences, and lag behind in mathematics, partly because of a lack of math-talk prior to coming to school (Levine et. al. 2010). We wanted to have a deeper understanding of how to present Geometry concepts in playful and engaging ways. We also wanted to link current research on spatial reasoning with our practice. We determined that spatial reasoning is a pillar of mathematics and we know that it is a predictor of later success in math. We want our students to be empowered as capable little mathematicians, and to think about their thinking (metacognition).

What do we know from the current research?
Spatial reasoning involves:

- 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. (Newcombe, 2010)
- "In our view, this spatial sense consists of three main components that are most essential for enabling young children to 'grasp the world' and to develop mathematical thinking: *spatial visualization*, geometry ('shapes' in short), and *spatial orientation* ('space' in short). These components can be recognized in the foundations of comprehensive mathematics curricula... (VanNess, 2007)

Aspects of spatial reasoning that have been identified (from IOSTEM working group on Spatial Reasoning, 2013)

- Symmetry
- Balancing

- Locating
- Orienting
- Decomposing/recomposing
- Shifting dimension
- Diagramming
- Continuity/connectedness
- Navigating
- Transformations
- Comparing
- Scaling
- "Feeling"
- Visualizing

According to the Ontario Curriculum, spatial reasoning is important, but as teachers we tend to typically focus on the standard language of shape and attributes of shape:

- Spatial sense is the intuitive awareness of one's surroundings and the objects in them.
- Spatial sense is necessary for understanding and appreciating the many geometric aspects of our world.
- Students develop their spatial sense by visualizing, drawing, and comparing shapes and figures in various positions.

We know spatial reasoning is important because it is an indicator of success not only in mathematics, but also in general intelligence, language acquisition, the ability to solve non-routine problems, and capacity for the STEM careers. (Newcombe, 2010; Casey, Nutall & Pezaris, 1992, 1997, 2001; Wheatley et al. 1994; Casey and Erkut 2005, Clements & Sarama, 2011)

We were encouraged to learn that spatial reasoning is malleable and even adults can develop and improve their spatial reasoning. Spatial reasoning can be learned through effective programming starting in the early years, but also later (Feng, 2007; Uttal et al, 2012). As part of our learning, we have been exploring math activities as a group and analyzing the benefits of a variety of math manipulatives to improve our understanding of early years spatial reasoning.

Evolution of our Research Questions

Month 1:

What are the connections between geometry and spatial sense in their (students') world?

Do students know the language (e.g., attributes)?

Are the students able to compose and decomposed irregular shapes?

Month 2:

Does physical practice improve mental ability to compose/decompose and perform mental rotations? (Levine)

How does gesture help?

Do gestures fall off as students get older?

Month 3:
What is student understanding of transformations (rotations and reflections in particular)?
Are students doing enough composing and decomposing of shape? (Inverse Levine)
What are our own gestures and how are they affecting student thinking and student gestures?

Month 4:
How do move from 2D thinking to 3D thinking (rotations and orientation and location)? (M4YC blocks transformation task)
How do students interpret photos of 3D figures compared to diagrams of 3D figures?
How can we prompt students to use more gestures in their mathematics?

References we found useful:
Newcombe, Picture This
Froebel's gifts in Kindergarten
Literature Review