A Playful Pedagogy Approach to Early Years Mathematics: Focus on Spatial Geometric Reasoning

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Math for Young Children Research Project

• The M4YC project began 7 years ago as a partnership with the Dr. Eric Jackman Institute of Child Study, the Robertson Program, OISE, Trent University and the Ministry of Education
• >2,500 students, > 150 teachers, principals, mathematics coaches
• 8 different school boards
• 5 on-reserve federal schools,
• Ministry personnel
M4YC 2012-Present

• **OBJECTIVES**
  • Broaden knowledge of math teaching and learning in early years focusing on geometry and spatial reasoning
  • Focus on under-resourced communities
  • Co-create resources for teachers across Ontario
  • Conduct research to test new lessons and activities
Young children’s Everyday/Informal Mathematics

- Counting numbers (ordinality)
- Subitizing to 3 or 4 (quantity recognition)
- Recognizing shape or change in shape
- Spatial sense, with emerging awareness of distance, height, location
- **Observed math play for 15 minutes in a classroom setting:**
  - 21% of the time, children explored pattern in shape
  - 13%, children explored magnitude
  - 12%, children explored enumeration
- *(Seo & Ginsburg, 2004)*
Early Mathematics for Equity

- Math skills at kindergarten a strong predictor of later academic success, including social studies and reading (Duncan et al, 2007).
- Growth in mathematical ability between kindergarten and first grade is an even stronger predictor of adolescent mathematics achievement.
- “Providing young children with extensive, high-quality early mathematics instruction can serve as a sound foundation for later learning and contribute to addressing long-term systemic inequities in educational outcomes.” National Research Council.
Spatial Thinking and Geometry for Equity

• Spatial thinking main predictor of, entry, success, creativity and innovation in STEM
• Aesthetic appeal: use of symmetries, beautiful figures and patterns
• Grounds mathematics understanding through body-related experiences
• Highly motivating offering multiple entry points.
• Provides strong and equitable foundation for mathematics learning.
Spatial Reasoning is Malleable

- Meta analysis of 217 studies over past three decades found an average effect size $= 0.47$. Effects found for all ages many types of interventions:
Unfortunately....

- Spatial thinking is an underserved area of mathematics instruction
- Despite the push for geometry and spatial thinking to be front and center in early years mathematics curricula
- Geometry very low priority for many teachers in K, 1 and when it is part of the curriculum the focus is on naming and sorting shapes--not on visual and transformational reasoning.
- Denying children opportunities
- Many talents go unnoticed!!
Our Dynamic Geometry Curriculum

-Symmetry
-Composing, Decomposing and Transforming 2-Dimensional Shape
-Composing, Decomposing and Transforming 3-Dimensional Objects
-Locating, Orienting, Mapping and Coding
-Perspective Taking

-Spatial focus
Spatial visualization
Mental rotation
Why focus on Symmetry?
Symmetry
Introducing Symmetry
Grid Symmetry Game
Composing, Decomposing and Transforming 2- and 3- Dimensional Shapes

What are the fewest number of pattern blocks needed to fill the figure on the right. What is the greatest number of blocks needed to fill the figure?
Composing and Decomposing
Spatial Approach to Measurement: Conservation of Area
Garden Tile Lesson
Students introduced to concepts of equivalence, congruence and transformations of 3-dimensional figures in lessons in which they were challenged to find the 28 unique figures that are composed of 5 interlocking cubes.
Pentomino Lesson: “The Magic Keys”
Exploring Congruence in 2-dimensions
Researching in Rainy River District

- 3 schools serving high proportion of FN students
- 2 schools Experimental Group = 38 students, SK - 3
- 1 school active control group = 28 students, SK - 3
- 6 teachers in each group

6 days full release both groups; Experimental Group spatial/geometry
Active control inquiry environmental science + 2 days math number PD
<table>
<thead>
<tr>
<th>Activities to Improve Spatial Reasoning</th>
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<tbody>
<tr>
<td>Fold and Cut Symmetry</td>
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<td>Big Pattern Block Symmetry</td>
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<td>Cookie Sheet Symmetry</td>
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<tr>
<td>Create Symmetry Half</td>
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<td>Pentomino Symmetry</td>
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<td>Grid Symmetry</td>
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<tr>
<td>Grid Symmetry Cookie Sheet</td>
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<td>Alphabet Symmetry</td>
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<td>Folding and Hole Punch</td>
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<td>Symmetry Concentration</td>
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<td>Magic Key/Pentomino Lesson</td>
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<td>Create Pentomino Puzzle</td>
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<td>Pattern Block Designs</td>
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<td>Hexagon Card Game</td>
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<td>Shape Transformer</td>
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<td>Can You Draw This?</td>
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<td>Tangram Shapes</td>
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<td><strong>Build it in Your Mind</strong></td>
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<td><strong>Building with Rules</strong></td>
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Average 45 hours over 7 months mostly on quick image activities
Results


* = sig. group x time interaction, $p < .05$
Results

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Graphs showing comparisons for Magnitude Comparison - Digits, Number Knowledge Test, and Vocab - PPVT between Experimental and Control groups, with pre and post-test data.
Playful Pedagogy in M4YC

- Playful/engaging contexts
  - Narratives
  - Fantasy
  - Game-like
- Important rigorous math
- Child-centered
- Authentic exploration
- Lots of choice
- Inquiry and discovery
- Problem oriented
- Action orientation
- Circle formation
- Visibility of learning
- “Engaging the collective”
Playful Pedagogy in M4YC

• **Structuring** of a learning context and materials around a particular set of developmental mathematical goals.

• **Leading responsive, inquiry-based** learning activities that include **exploration** with specific objects/materials that stimulate children’s **curiosity, engagement, and sense making**.

*SK exploration of Proportional Reasoning*
Thank You
Carried out another intervention study, but made some changes:

- New schools (same board)
- More teachers \((n = 10)\)
- More measures, including standardized Canadian normed math assessments
- More child participants \((\text{experimental } n = 85)\)
Year 2: Results Geometry and Numeration

Key Math

Improvements in Geometry Performance

Improvements in Numeration Performance