Gaa-maamawi-asigagindaasoyang:
Doing math together

Research Results
2015

Gaa-maamawi-asigagindaasoyang[1]**:** *Doing math together*
Rainy River District School Board Research Project

General Overview of Project and Research Design
A central goal of this year's research was to continue to evaluate the effects of our Inquiry-Based Mathematics Teacher Professional Development (PD) model. Last year, we found significant growth in both spatial and mathematical thinking in the students' whose teachers participated in the PD. This year we looked to extend this work by including new assessment (outcome) measures and working with new schools within the Rainy River District School Board (RRDSB).
Our research results (pages 7 – 9) **are very exciting!**

Measures

The following is a brief summary of the measures that we used to assess student learning outcomes.

1. Spatial Language In this measure, students were asked to identify spatial locations Fig. 1 below) and simple shapes (see Fig. 2 below).

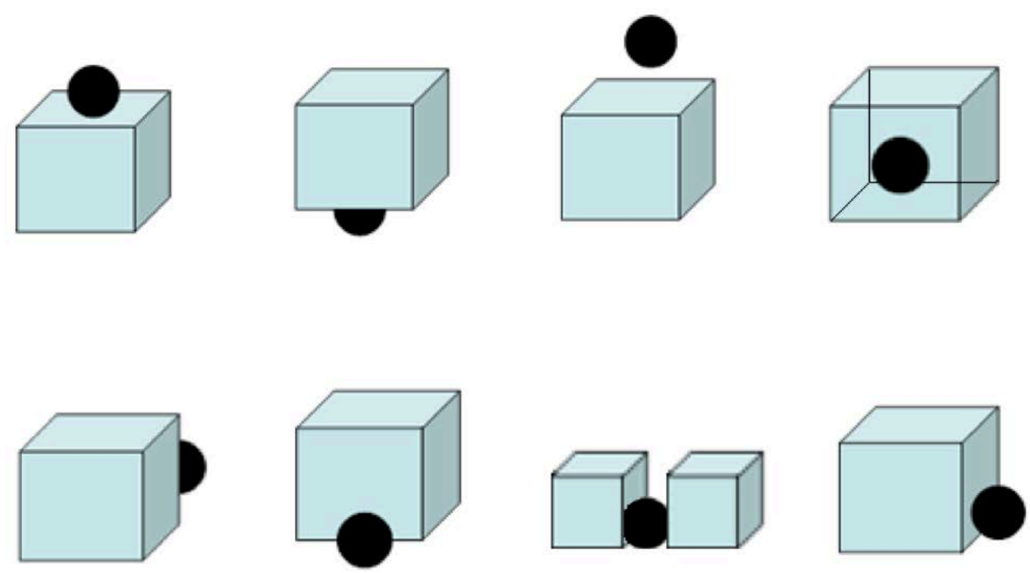


Figure 1. Students were asked to "point to the picture that shows the ball: beside the box, inside the box, on top of the box, etc. "

[1] A new word for mathematics, coined by Jason Jones in February, 2015.

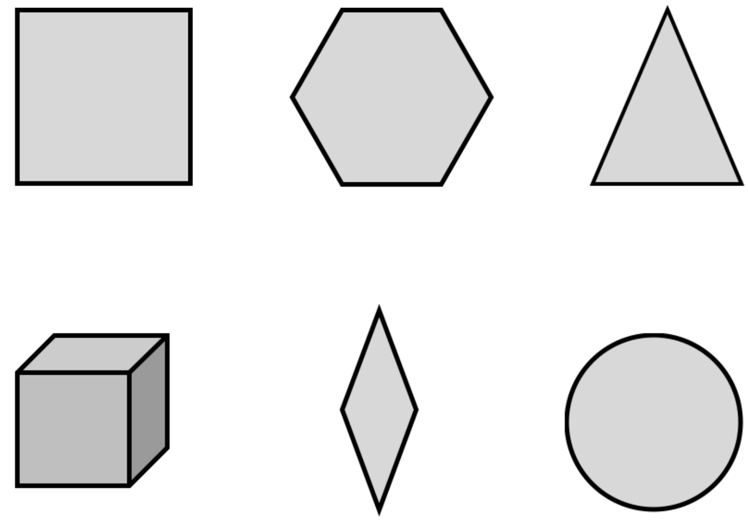
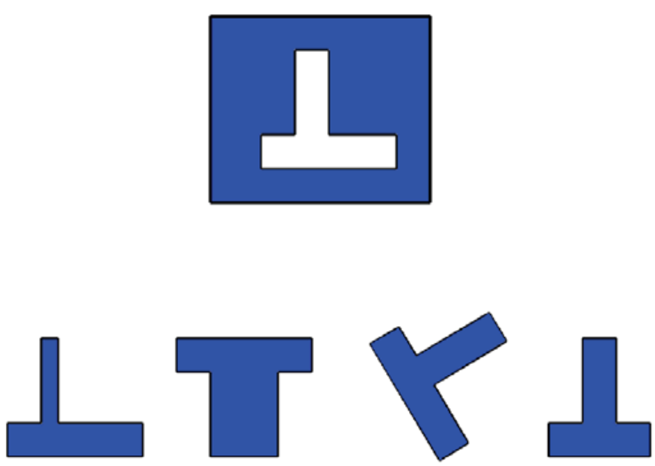
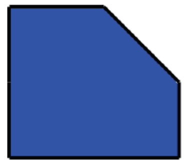


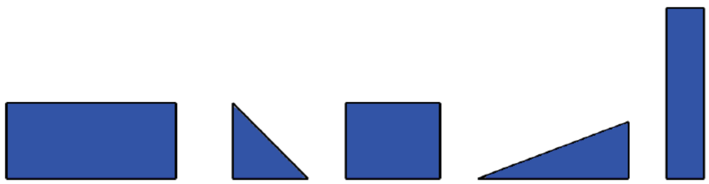
Figure 2. Students were simply asked to identify each shape.

2. Visual-spatial Geometry Assessment This measure was made of 20 questions that required students to engage in spatial visualization. See Figure 3 below for a sample of some of the questions children were asked.

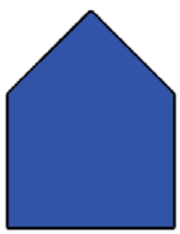


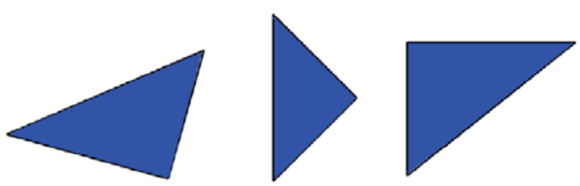
Question: Point to piece that can be made to fit in the white space above*.*



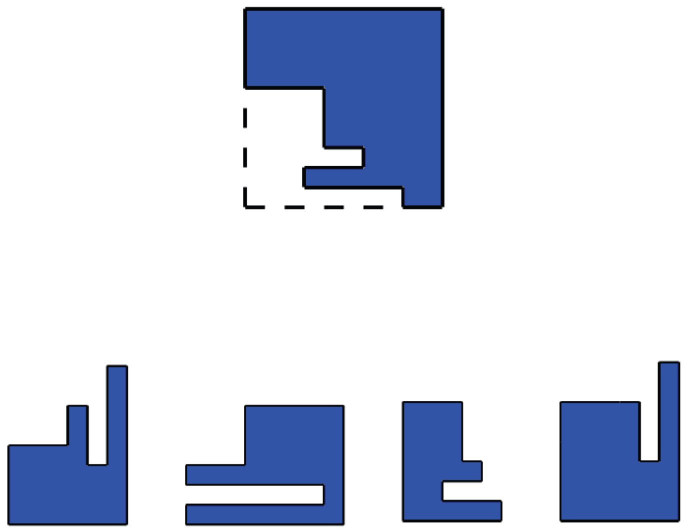


Question: Point to the three shapes that can be put together to make the shape above.



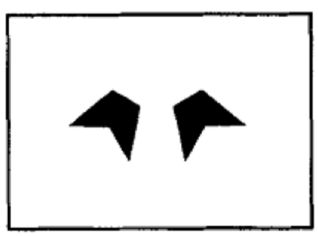


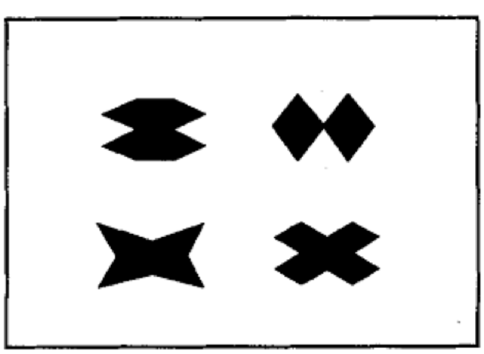
Question: Using your finger, show me where you would have to cut this shape (point to the shape above) to get these three shapes.



Question: This puzzle is missing a piece. Point to the missing piece.

3. 2D Mental Rotation Task This task is a highly used measure of young children's spatial reasoning skills. The task was developed by Susan Levine and colleagues at the University of Chicago.





Question: Point to the picture that the two pieces (above) make.

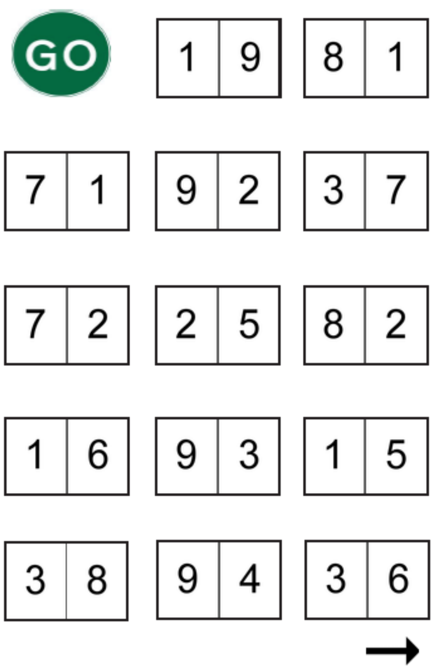
4. Number Knowledge Test This test developed by psychologists Robbie Case and Yukari Okamoto and is a standardized (based on Canadian normative samples) assessment of young children's number knowledge. All questions are administered orally and thus assess children's mental numerical processing skills. Below are three example questions:

What number comes right after 8?

How many numbers are there in between 7 and 9?

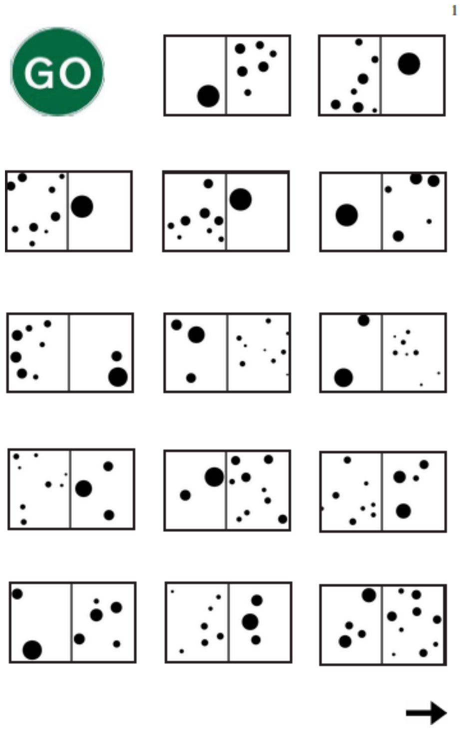
How much is 12 plus 44?

5. Numerical Comparison with Numbers This measure was developed by psychologists and neuroscientists Nadia Nosworthy and Daniel Ansari. The measure is said to assess basic numerical processing skills and is strongly related to mathematics achievement.



Question: Children are provided with a pencil and must cross off the larger of two numbers (e.g., 1 vs. 9). Children are given 1 minute to complete as many items as possible. Both accuracy and speed are emphasized in the instructions.

6. Numerical Comparison with Dots (Approximate Number System) This measure is identical to the one above but includes dots as stimuli instead of Arabic numerals. This nonverbal measure is commonly used to assess one's 'number sense' – a foundational skill in which mathematics is thought to build upon.

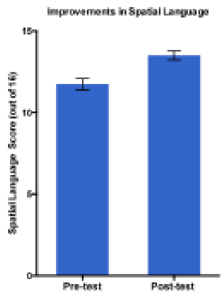


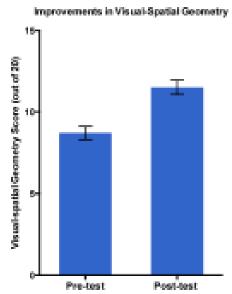
Question: Children are provided with a pencil and must cross off the larger of two dot arrangements (e.g., 1 dot vs. 6 dots). Children are given 1 minute to complete as many items as possible. Both accuracy and speed are emphasized in the instructions.

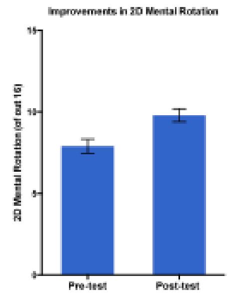
7. Peabody Picture Vocabulary Test (PPVT) This is a widely used test of vocabulary. The measure is sometimes used as a proxy for general intelligence. The test-taker is shown four pictures and then must point to the picture that best represents the meaning of a given word. We included this measure in our battery of assessments to control for vocabulary when carrying out our statistical analyses.

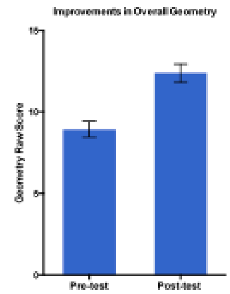
Summary of Results

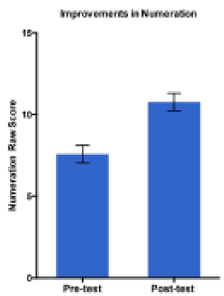
We are delighted to present our exciting research results from our work in Kindergarten to Grade 3 classrooms in 5 schools that serve 6 First Nation communities. The following graphs show the impressive **overall improvements** from pre-test to post-test **on all eight measures**. On every measure, children demonstrated **statistically significant** improvements.

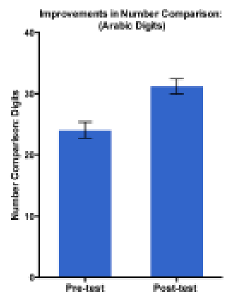


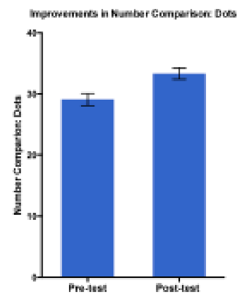


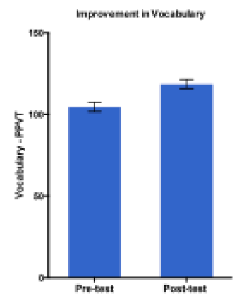




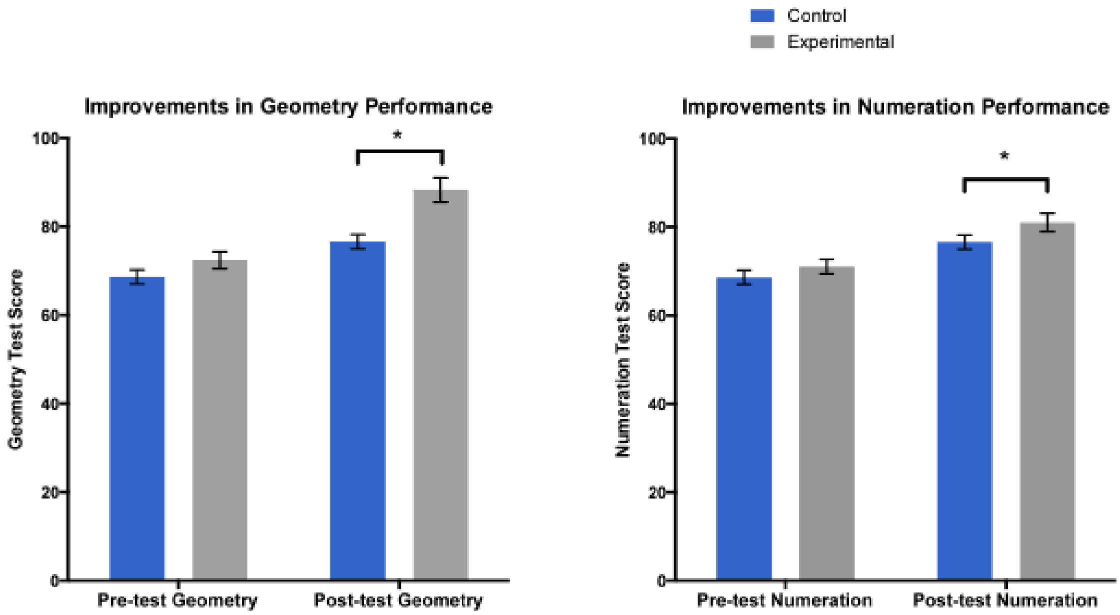








To further determine whether these improvements were merely a result of development and not necessarily a consequence of the seven-month PD intervention, we carried out analyses on the two KeyMath measures and compared performance and growth between the students that we worked with to matched controls (i.e., average Canadian child of the same age). In the following graphs, you can see that at pre-test the experimental group (children we worked with) did not differ significantly from the control group (i.e., typical Canadian child of the same age). That is, at the beginning of the year, there was no difference in performance between the children we were about to work with and the average child of the same age. In statistical terms, both groups of children might be considered as coming from the 'same population.' However, as you can also see in the graphs, a **significant difference between the groups** was present at the end of the year (post-test). Children in the experimental classrooms **significantly outperformed** the expected performance for their age. In statistical terms, the two groups of children (experimental vs. control) would be considered coming from 'different populations.' Thus, there is evidence to suggest that the intervention (seven-month Robertson Program math PD) had a **significant effect on students' overall performance in both Geometry and Numeration.** In summary, while the children we worked with began the year within an expected range of performance, by the end of the year, the children we worked with were performing at a level significantly higher than could be expected.



Summary of Results
Our yearlong effort to increase student achievement in spatial reasoning and mathematics was successful. Our findings suggest that **employing an inquiry-based approach to early mathematics** with a major emphasis placed on increasing students' **spatial reasoning** skills offers an effective means to **improve student achievement in mathematics**. Children who took part in the spatial approach to mathematics demonstrated **remarkable gains** in their spatial reasoning abilities. Given the importance of spatial reasoning for concurrent and later mathematics and science performance, this finding is meaningful and potentially far reaching (i.e., acquiring spatial thinking skills early in schooling may pay dividends later on). A noteworthy finding was that a spatial approach to mathematics was effective in bringing about improvements on the numerical comparison measure. To our knowledge, this is **the first study** to show that improvements in a foundational understanding of number can be **achieved** through a **spatial approach** to early mathematics instruction. Overall, we are optimistic that our intervention has helped place children on a learning trajectory that will likely yield many positive outcomes in future experiences with mathematics.

Publications

The following publication has been accepted by a peer-reviewed scholarly journal and highlights our partnership with the Rainy River DSB (with Sharla MacKinnon as co-author):

Hawes, Z., Moss, J., Caswell, B., Naqvi, S., & MacKinnon, S. (in press). Enhancing children's spatial and numerical skills through a dynamic spatial approach to early geometry instruction: Effects of a seven-month intervention. *Cognition and Instruction.*