NORTHUMBERLAND LESSON STUDY TEAM
KPRDSB
Kindergarten to Grade 2
April 13, 2012

Research Question(s):

What kinds of geometry are children exploring during block play?

What kinds of geometry tasks help young children beyond naming and sorting shapes?

What processes and spatial reasoning strategies are children using when they are visualizing during geometry tasks?

KAWARTHA PINE RIDGE
DISTRICT SCHOOL BOARD

Teacher-Researcher Team:

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Discussant: Claire Mooney, Trent University

AGENDA	
9:30 to 11:00	Introductions and background provided by the planning team
11:00 to 11:30	Break and Networking
11:30 to 12:15	Public Lesson
12:15 to 1:30	Debrief: i. Teachers who taught lesson ii. Observers from teacher planning group iii. Comments from guests iv. Discussant

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Background Information

1. Clinical interviews

TASK 1: Composing and Recomposing Figures 2D (filling space)

Show student the butterfly outline on the page:
"This is the outline of a butterfly. Use pattern blocks to fill the space and make the butterfly."
Provide student with bucket of pattern blocks of all shapes.
Once butterfly shape is filled, carefully slide the pattern block butterfly to the side.

Present student with a second butterfly outline that is the same on a new page.
"Here is the same outline of a butterfly. Now use the pattern blocks in this bucket to fill the space in a different way."
Provide student with bucket of pattern blocks, again with all shapes.
Carefully slide the previous pattern block butterfly beside the new one.
When student is done:
Tell me about your two butterflies. [How are they the same and how are they different?]

TASK 2: Composing and Recomposing Figures 3D (building structures)

Show a picture of a boat made with blocks (Only if necessary: remove base for younger children)
"Now make this boat with these blocks"
Provide a bucket of blocks with more blocks than needed.
When student has finished: "Tell me what you did."
[Additional prompt: How did you know where to place this block?" Point to a block somewhere in the structure near the middle.]

OPTIONAL DEPENDING ON TIME
"Now use your same blocks to make something different."
As soon as they place one block.
STOP them.
"Stop for a minute please. Now tell me, what are you seeing in your mind?"
Listen to student. Perhaps do not get them to build in the interest of time

Task 3: Movement and Orientation (Orientation)
Series of steps: See it, cover it, recreate it, check it, talk about it (from the original visual)

Before beginning this task, empty the bag of arrows and shapes and rearrange into separated piles of like shapes (4 like shapes per pile….e.g., 4 squares).

When presenting the design cards arrange in a way that the label (e.g., *Challenge 1a*) is located in the top left corner of the design.

"I'm going to show you a design. You will be given a short time to look at the design and then it will be covered. With these shapes (point to them) try to make the *same* design as the one you saw."

With some patterns: How did you remember the pattern?

Show the design and count 5 seconds in your head, then turn the picture over. Repeat.

When student is done what appears to be a level that is challenging to him/her:
(Not for every pattern)

"Tell me what you did."
"Now check your design with the picture. Are they the same? Are they different?
How do you know?"

Revealed a lot about spatial orientation and how students had to hold so many things in their mind

- Shapes
- Number of shapes
- Relative position
- Orientation
- Planes
- Point of reference

Lack of use of math language was a big eye-opener. Students were not able to communicate their strategies for completing the task.

Strategies that were observed to enable student success were: verbal rehearsal (usually sequential), gestalt (simultaneous information processing) including identifying negative space, finding an anchor and building out (relative starting point).

Students were able to hold one or two things but more than that was a challenge.

Examples:
Clip: Hailey: "I said in my mind…"
Boy who used verbal rehearsal: "because I went circle rectangle triangle." His representation had errors. When he checked his work, he stated "I remembered all the shapes but I couldn't remember where they go."
Negative space: "because I saw this in the middle"

Task had a high cognitive load: memory, shape, number of each shape, orientation, relative location, ability to reproduce.
Physical manipulation of shape and exploration are key.

Task 4: Movement and Orientation (movement)

Present student with the 5 x 5 grid. Recreate 'Challenge #1' (see cue cards).
"We are going to play a game. This is a parking lot. Here is the exit and the car is stuck because of the trucks (point to the blue blocks). Your job is to move the car out of the parking lot to the exit. You can only drive in a straight line. Your job is to figure out how to move the trucks in order to get the car out of the parking lot. Remember: Cars and trucks can only go forward and backward."

Present the student with the 5 x 5 grid and truck/car arrangements according to the challenge numbers (Challenge #1 = easy, Challenge #8 = extremely difficult).
We suggest 1, 4, & 8 (but adjust for JK and SK as needed)
Continue to administer "challenges" until the challenge is clearly too difficult for the child.

Note: If the child is having difficulty remembering that the 'blue trucks' (blue rectangular cards) can only move in the direction of the track they are on, point out that the black arrows on the cards help show the direction the trucks move in.

How did you figure out what to do?

Parking lot task was interesting to observe – underscored the importance of watching students closely.
Students had to think ahead, beyond one move to get the car out of the parking lot.
Tasks were increasingly more difficult and some young children were able to work through the entire set!

2. Literature Background

Mannamaa, M., Kikas, E., Peets, K. & Palu, A. (2011). Cognitive correlates of math skills in theird-grade students. *Educational Psychology: An international journal of experimental educational psychology 32* (1), 21-44.

Sequential processing occurs when a person thinks about the sequence (of objects in our case), one at a time. So 'gee I am looking at a circle, then a square, then a trapezoid and another square'. *Simultaneous processing* occurs when a person thinks about multiple objects at the same time, often using a gestalt strategy (recognizing the form as a whole and usually connecting that to something familiar such as 'oh that looks like a dog').
Students who can use simultaneous processing have greater success with problem solving AND inferencing from text. What we have observed is that some students rely on sequential processing, while others use simultaneous information processing and can move flexibly between the two. One thing we want to pay attention to during the public research lesson is - which students are using sequential, simultaneous, both? and in what circumstances?

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

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.

Ferrara, K., Hirsh-Pasek, K., Newcombe, N., Michnick Golinkoff, R., & Shallcross Lam, W. (2011). Spatial language during block play. Spatial intelligence and learning centre, available online: http://spatiallearning.org/index.php/showcase/144-showcase-october-2011-spatial-language-during-block-play

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.

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

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.

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

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.

Algebra:

- 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

Additional publications of influence:

Clements, D. H., & Sarama, J. (2009). *Learning and teaching early math: The learning trajectories approach.* New York: Routledge.

Sarama, J. & Clements, D. (2008). Mathematics in early childhood. In O. Saracho & B. Spodek (Eds.), *Contemporary Perspectives on Mathematics in Early Childhood Education*. Charlotte, NC: Information Age Publishing: 67-94.

Sarama, J., & Clements, D. H. (2009). Teaching math in the primary grades: The learning trajectories approach. *Young Children, 64*(2), 63-65.

Sarama, J., & Clements, D. H. (2009). *Early childhood mathematics education research: Learning trajectories for young children.* New York: Routledge.

Sarama, J., & Clements, D. H. (2009). Building blocks and cognitive building blocks: Playing to know the world mathematically. *American Journal of Play, 1,* 313-337.

3. Exploratory lessons

1. First we observed Block Play:

Not much math language or specific math concepts featured by the students in free block play
Testing and prediction of structures
Always a familiar structure
Difference between males and females
Dominance where one person controlled – not as collaborative in some observations
Not communicating – parallel play (especially boys)
Learning happened when the teacher was there, not just playing on their own, but using that language WITH students

<u>6 Ways to "Play" with Block Play to Enhance Mathematical Thinking</u>

After observing students at free play with blocks in JK to Grade 2 classrooms, the Northumberland team concluded that the children did not engage in explicit math thinking, but rather implicit understandings. We could see math thought went into their building, but didn't always hear their thinking, - not much math talk. Children's block play seems to be full of informal understanding of geometry and math, but more can be done to "pull out" the meaning from these natural understandings and make it explicit.
The team generated 6 scenarios for setting parameters on block play that might encourage students to "play with math ideas more fully during block play". The following scenarios, based on observations, may encourage MORE math thinking and use of math language:

Scenario 1: to focus on balance, weight, measurement and problem solving
You structure must have a moving part

Scenario 2: to focus on stability and problem solving
Make a tower using this bucket of materials only

Scenario 3: to focus on fit, spatial relationships, stability and problem solving
Design one garage/stable for each truck/horse (provide two horses or trucks of very different sizes).

Scenario 4: focus on stability and measurement and problem solving
Make a bridge / tower with a base of cylinders and then a second one with a base of pyramids.
Make some comparisons, using the different figures and testing them.
Is one tower / bridge more stable?

Scenario 5: to focus on math language of positions and spatial sense
Follow the blueprint to build your structure (provide a map and appropriate assorted blocks including those needed for the blueprint and some extras not needed according to the blueprint).

Scenario 6: Spatial sense and problem solving
Put away the blocks within the tape lines.
Put tape on walls and floor as guidelines for the space in which the blocks must fit.

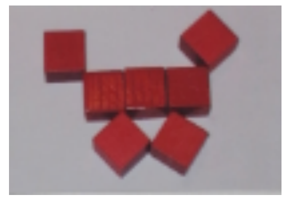
2. Dog lesson

Visualizing – verbalizing – verifying helped
Showed the problems around orientation:
Could get the general outline but the fine tuning of the orientation was hard.
Seeing different things in that design – seeing another person's point of view
Was it limiting – couldn't break out of what they saw
That pushed the language piece again

OBSERVATIONS:

Whole group teaching was not effective.

Need intensive small group to be able to respond to what children come up with and provide that language.



"Dog" lesson with coloured tiles

Lesson goal:

This would be a whole group lesson before playing a barrier game, to get kids to start copying with the visual first (emphasis on visualizing and verbalizing, not memory, scaffolded with the visual present before that is removed in a later barrier game activity like master builder). Emphasis on multiple strategies for "seeing".

Materials:

Cubes of all one colour
Paper copy of "dog" picture for each pair
Mat for working on

Activating:

Show the "dog"
Ask: What do *you* see?
Everybody turn and talk.
Come back to whole group:
Do doodling or circling or marking
Pulling out the different perspectives.

What way helps you to remember?
Can you see it that way?

Developing:

Cover the dog. Get them to build with a partner at their table.
Encourage a lot of talk: make sure you and your partner agree that it's the same.

Consolidating:

Show the picture again and compare.
Show the teacher example and ask students about it (orientation of head and tail deliberately switched): is this the same? How is it different?

Key Questions:

What way helps you to remember?
Can you see it that way?
What is it you see?
Can you see that?
Can you come up and frame it?
Can you see where the legs are?
Can you see it *now?* Can *everybody* see it?
[if not] you are going to have to explain it more!
What helped you build it?
Can you remember that?
Where did you start?

3a. Grids and Shapes (Jk-1)

Moved on to more abstract shapes – wanted to get away from recognizable objects

<u>Activity i</u>

We used a grid and showed 6 shapes in the grid.
No problems with the familiar shapes (heart, star, arrow, circle, arrows) - names for these shapes (used language to reduce the cognitive load)
Problems using pattern blocks
Covered it over and recreate
Scaffold to describe the placement – (grid); hypothesis – this supported students in their understanding
Had a "Shape Directions Task"
Students managed the shapes in part 2 after having played the partner game

<u>Activity ii</u>

Tangram shapes – first one looked like a tree (two big triangles, two small triangles)
JK – were challenged with this. Took it apart and made something simpler (two triangles in a line) – tried to attach meaning to it. But couldn't articulate positions.
I have 1 big triangle and 2 small – is it the same? Then students were able to talk about positions.

Triangle, square, Triangle: I see a square. And the rotation of the triangle was the hardest thing for them to figure out. Turned one triangle and they were able to get it. SKs had a challenge using the directions and positions.
What were you getting at with the students: wanted them to think about positions and locations, not just the image. Three shapes are related to one another but not as a narrative image.

Flexible thinking between full image and separate figures and their orientation/arrangement.

<u>Activity iii</u>

Use pattern blocks (figures combined to make 'dog' – gestalt visualization)
Pointing out to students the pattern block shapes (and negative space)
Made some pattern block figures with negative space, triangle space amongst the pattern block shapes. Colours helped her too.
Used language such as below, above.
Do you notice anything here? Oh the space of the triangle. By direct teaching, student was able to see it.
Same and different – looking to see what is the same and what is different?

3b. Transformations (Gr 2)

Activity i

Materials:

1) 10x10 grid on learning carpet
2) Arrows
3) Cartesian plane mapped out on learning carpet to demonstrate turns
4) Mini 10x10 grid booklet

Steps:

1) Model for the children what the turns at different degrees look like using the Cartesian plane on the learning carpet. The types of turns include: "quarter-turn", "half-turn", "three-quarter turn" (?)
2) Tell the children, "Using this arrow, I wonder what a "__________" would look like if the arrow starts at this position (provide reference point"
3) Before the children are allowed to demonstrate the move from Step 2, ask them to visualize it and then draw where the arrow would end up in the mini 10x10 grid booklet
4) After drawing the move, have the children show it on the learning carpet
5) Repeat steps 2-4

Sequence of Transformations:

1) 1 Translation
2) 2 Translations
3) 1 Rotation
4) 2 Rotations
5) Combination of 2-4 translations and rotations

Question for Deb and Charlene:

- Setting up a fixed point of reference?

Activity ii: Pairs Practice

Materials:

1) Two 10x10 grids
2) Cards describing different transformations
3) Arrows
4) Popsicle sticks labeled 'Visualize', 'Verbalize', 'Verify'

Steps:

1) One partner chooses a card.
2) The child visualizes the transformation, explain how he/she would make the move on the 10x10 grid
3) The child would then trace where the arrow starts on the grid by identifying the reference point, perform the transformation and glue the arrow in its final position
4) Both partners would then verify the move
5) The other partner repeats steps 1-4

Question for Deb and Charlene:

Fixed reference point for each transformation? That might make it easier for the kids to verify the moves after

Key Learning:

We have observed two types of processing which is also supported in the literature:
Simultaneous Information Processing
Sequential Information Processing

- Simultaneous is being able to see the gestalt and the relationships of parts
- Sequential is being able to see the parts individually

Many people naturally see 'whole pictures' but don't necessarily use this in their mathematics work.
We need to get students to see the component parts and the whole.
We want students to be flexible users of strategies.

PUBLIC RESEARCH LESSON PLAN

Students: 10

Lesson Goals:

- Provide opportunities for children to practice both simultaneous and successive information processing
- Have children practice their geometric language and communicating using this language in a collaborative context
- Learn more about how children think about spatial reasoning and visualization and how to help them improve on these skills

Rationale:

When we were interviewing students in the task-based interviews, we noticed that some relied on successive information processing and some used *gestalt* to make sense of these complicated figures they were being asked to replicate. Then we learned that the idea of gestalt and thinking about spatial groups is a huge part of problem solving and complex math as well as reading comprehension. We've tried a lot of things as a team in the exploratory lessons; students are now ready to try something more complex. In the initial tasks, they weren't using the language and irregular shapes so all our exploratory work has built up to them being able to do this. This task requires flexibility in their thinking and we have worked to provide opportunities for students to build process information simultaneously as well as successively (in this task students have to think about the directions and the steps but also about the overall image).

Expectations:

Overall: Compose and decompose 2d shapes and 3d figures

Specific:

- Patterns pictures and designs using common 2 d shapes
- Describe the relative location of objects
- Sort and classify shapes by their attributes
- Identify common shapes
- Processes: developing vocabulary, reasoning skills, communication, investigate conjectures

Exploration/Familiarization Prior to the Public Lesson

Get some shapes
Make something
Gallery Walk – what do you see?
Discussion

- What do you think ___ made?
- Can you describe it to us?

Public Lesson

10 students - 4 "experts" who did practice of public lesson but using "snowplow" model as activation and 6 "newbies". "Expert" group is made up of students who we thought might find the activity challenging and related prior experience might help them succeed at the task.

Experts will be seated at 1 table so it will be interesting for observers to notice any differences between the groups and see if the prior experience has aided in their success with this challenging activity!

***Materials*:**
barriers (portfolio writing folders)
cookie sheets; foam shapes; directional triangles; photocopies of 5 figures to choose from to build

Activating ideas – at carpet: Whole class
Look at Smartboard - screen 1 - (random mosiac puzzle shapes; anchor charts of positional words and words to describe shapes as sidebars; directional triangle)
read lists over together to remind students of descriptive language

Look at Smartboard - screen 2 - Partially made figure on SB (and with foam on magnets as a backup)
Give explicit instructions to one student to build.
Use 1st "expert" student to help Mrs. Moher give directions to complete person figure she has on hidden cookie sheet. Use 2nd "expert" student to assist Miss Morrison in selecting shapes on Smartboard and Miss Morrison will move them into place as directed by this student. This will allow student participation and yet speedy movement of the shapes. Grade 1 students have some difficulty moving the shapes without letting go of them and have not had enough experience with rotation them on the screen to be successful in showing an audience.

Ask them, "What do you see?"

Developing ideas: (barrier game) at tables (all set up and ready to go)
Using class anchor chart of How to Play the Barrier Game, go over instructions and role of speaker/listener, and introduce the pre-set picture cards before sending them off to play the game.

Reminders about instructions:

i. Choose 1 of the picture cards
ii. Quickly put those shapes on your cookie sheet to match the card; use your cookie sheet vertically or horizontally as indicated by the picture card
iii. Then give directions to build the figure to your partner
iii. Your partner makes it
iv. Remove barrier and compare
v. What do you see?
vi. Revise as needed

Additional instructions

- sit side by side
- one turn each

Consolidating ideas – back to the carpet

Students may be at different stages in process of playing the game when we call them back together. Some may not have a finished picture to share on the carpet but the task cards could be used for discussion purposes if need be. Finalized pictures to be shared during the consolidation can be placed on chalkboard ledge for others to see.

Need to bring back to carpet: Cookie sheets and magnets

Ask students who are sharing to point to picture they created on cookie sheet or task card used so a visual is available as the following questions are asked.

Discussion: Key questions – possibly on SMARTboard during the consolidation phase

Where did you start?
Why did you start there?
What was your brain doing while your partner was giving you directions?
What was your brain doing while you were giving directions?
What helped you?
What did your partner do that helped you?
When did you have to ask for more information?
Where you surprised by anything?

OBSERVATION GUIDES

1. Vocabulary and gestures
   - Shape names/describing shapes

2. Communication:
   a. Asking clarifying questions
   b. collaboration

3. Spatial reasoning
   a. Evidence of visualization: do they talk about shapes
   b. Use of space: Anchor point
   c. Position and orientation

4. Simultaneous /successive information processing
   - Following directions/Provide instruction
   - Organization of language, thoughts

   * One person from the team observing each pair.

Date: April 13, 2012
Name:

Observation Guide I: Vocabulary and Gestures

RECORD STUDENT LANGUAGE AND GESTURES AS THEY ACCOMPLISH THE TASK:

LANGUAGE: (esp. math language: shapes, orientation, direction)

HOW ARE STUDENTS USING GESTURE TO MAKE MEANING OF THE TASK?

Date: April 13, 2012
Name:

Observation Guide 2: Communication

How are students collaborating to accomplish the task?

Are students asking clarifying questions of peers?

Date: April 13, 2012
Name:

Observation Guide 3: Spatial Reasoning

Evidence of visualization: what visualization strategies are students using to deal with shapes?
Use of space (eg. Using anchor point?)
Position and orientation (What are some challenges? Strategies?)

Date: April 13, 2012
Name:

Observation Guide 4:
Simultaneous and sequential information processing

Sequential processing occurs when a person thinks about the sequence (of objects in our case), one at a time. So 'gee I am looking at a circle, then a square, then a trapezoid and another square'.

Simultaneous processing occurs when a person thinks about multiple objects at the same time, often using a gestalt strategy (recognizing the form as a whole and usually connecting that to something familiar such as 'oh that looks like a dog').

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HOW DO STUDENTS PROCESS/PROVIDE INSTRUCTIONS?

OBSERVATIONS OF ORGANIZATION OF THOUGHTS/LANGUAGE: