How Does Arts Integrated Instruction Impact Analytical Seeing, Geometry, and Spatial Reasoning? A Study of Moving Through Math Inspired Lessons that Focus on Children's Conceptual Reasoning.

Area of Focus

In Waterloo, Iowa, students use pattern blocks to learn about shapes and structures, analyze their characteristics, construct and manipulate mental representation of objects, and develop mathematical language to communicate their understanding of shapes. Investigations curriculum is used to further support student's construction of knowledge. The Iowa Core grade 3 overview expects students to reason with shapes and their attributes (Iowa Core Mathematics, 2012). However, with all the experiences provided within the core instruction, students continue to struggle with analytical seeing geometry, and spatial reasoning.

The Waterloo district provides intensive after school instruction called FLASH. The FLASH program allows teachers to pre-assess students in the areas of math and reading to determine participants. The FLASH program provides 6 – 8 sessions of intensive and supplemental instruction based on area of need. The instructional decision is based on the FLASH instructor, but must align with district and Iowa Core standards.

Based on the FLASH data of 2012, subgroups made little to no gain in the area of geometry and spatial reasoning based on the Iowa Assessment results. In addition, third graders at Kittrell Elementary in Waterloo displayed below proficient scores in the area geometry. Scores were significantly lower for low SES students.

The variable that has more flexibility and little monitoring is the content of FLASH instruction. It is my argument that FLASH be differentiated to meet the various learning modalities. The district is addressing the need to increase depth of knowledge through classroom discussions (Chapin, et al, 2009), and implementing the five practices for orchestrating math discussions (Smith and Stein, 2011). However, the core curriculum has little opportunity for kinesthetic application. Moving through math lessons, created by Marcia Daft (2011), address Howard Gardner's theory of multiple intelligences (1983) as students actively experience math concepts.

Purpose of Study

As a correlation emerged between geometry/spatial reasoning and subgroups, I decided to apply Marcia Daft's *Meet the Shape Family* lessons during a 6 week FLASH group. To determine the students that would participate in the study, I looked at the second grade end of unit results and identified students that were non-proficient in the target concept. In addition, I met with third grade teachers to discuss students that might benefit from differentiated sessions that support bodily or kinesthetic experiences. The Iowa Assessment was a driving force, but was not measured for the purpose of this study due to the time frame in which results would be returned from the state department.

The purpose of the study was to provide six weeks of differentiated instruction that would build a conceptual understanding through varied modes. Half of the participants have little English, and all participants struggle with math language when sharing their reasoning during classroom discussion. Although a performance assessment was not measured, it was my belief that if the students had a conceptual understanding of geometry and math language to explain their thinking, they would increase their participation in classroom discussion.

Review of Literature

Pattern blocks are used in the Investigation curriculum. As students use geometry tools, such as pattern blocks, the National Council of Teachers of Mathematics call that geometric understanding (2000). Geometric knowledge can help children understand other aspects of mathematics, such as fractions and graphs. The foundation of geometric reasoning supports the thinking that continues with fourth and fifth grade math concepts. In addition, the depth of knowledge builds to include strategic thinking/reasoning and extended thinking (Iowa Core, 2013).

Jean Piaget's developmental theory provides insight into children's developing spatial and geometric conceptual understanding (DeVries, et al, 2002). This research demonstrates that young children have limited conceptual understanding of space (Piaget & Inhelder, 1948/1956). Children construct knowledge on a practical level before they construct it on a conceptual level (DeVries, et al, 2002). To support the developmental transition from practical to conceptual, additional tools such as large bands are used in *Moving Through Math* (Daft, 2011) to allow students to see, hear, discuss and feel geometry and spatial concepts.

The current district initiatives extend the core curriculum through classroom discussions (Chapin, et al, 2009) and practices for orchestrating productive mathematics discussions (Smith & Stein, 2011). Chapin, et al identify ways in which to push learners beyond incomplete, shallow, or passive understanding by incorporating student talk into lessons about the ideas they are trying to understand (p. 7). Smith and Stein promote depth of knowledge through selecting, sequencing, and connecting to unearth, probe, and stimulate student thinking (p. 73). The tiered approach to selecting and sequencing, along with the math talks support readiness as an example of differentiated instruction. In addition, student interest and choice could be cultivated as students share their thinking with peers in a non-threatening environment that focuses on student thinking versus correct answer. However, the learning profile (Tomlinson & McTighe, 2006) may not always be addressed through the tools provided in the Investigation kit. Some of the factors that might be overlooked could include neurological patterns such as attention control, memory systems, language systems, sequential and spatial ordering systems, and social thinking systems (p. 182).

The geometry lessons included in Marcia Daft's *Meet the Shape Family (*Daft, 2006) provide modes (Gardner, 1997) of learning that extend beyond the core curriculum. Arts integrated instruction provides students with a varied approach that acknowledges the barriers associated with the learning profile while supporting district math initiatives regarding questioning and math talks.

Description/Timeline of Study

The focus group for this study was eight students from three different third grade classrooms at Kittrell Elementary in Waterloo. Three of the students receive ELL services, and seven of the students receive Title One services. All eight students were recommended for the FLASH program based on end of unit math scores at the non-proficient level. In addition, five of the students scored non-proficient on the second grade end of unit assessment on geometry given in the spring of 2012. Three of the students were new to Kittrell this year and one student was new to the country.

All students completed an analytical seeing/visual problem solving inventory during the first 15 minutes of session one. Following the pretest, students were introduced to brother triangle (appendix A) through the use of character development and a flexible band. The band is constructed from the bottom of a t-shirt and sewn together at the ends. The band is stretchy to accommodate the size of the participant. Students discover various ways to create a triangle with the band using their arms, legs, and head. All students are active participants and language is not a barrier. As students explore the properties of their band they begin to use them for a purpose.

The language of math provides students with a way to describe what brother triangle is doing when he is on his head. One student uses the term "flip" when explaining the base of the triangle (brother triangles bottom), the students then incorporate the term flip into their explanation. Brother triangle plays with a bow and arrow, and students recognize the base is now a vertical line versus a horizontal. The term rotation quickly follows. Once the students experience the shape kinesthetically, the language of math follows with specific explanations during the performance: create a story that has a beginning, middle, and end that includes three different brother triangle characters.

During the first two sessions, students explore the properties of the band and begin to use the tool for a purpose: to create geometric shapes. Students observe as I present flips, turns, and rotations through a narrative about brother triangle's behavior.

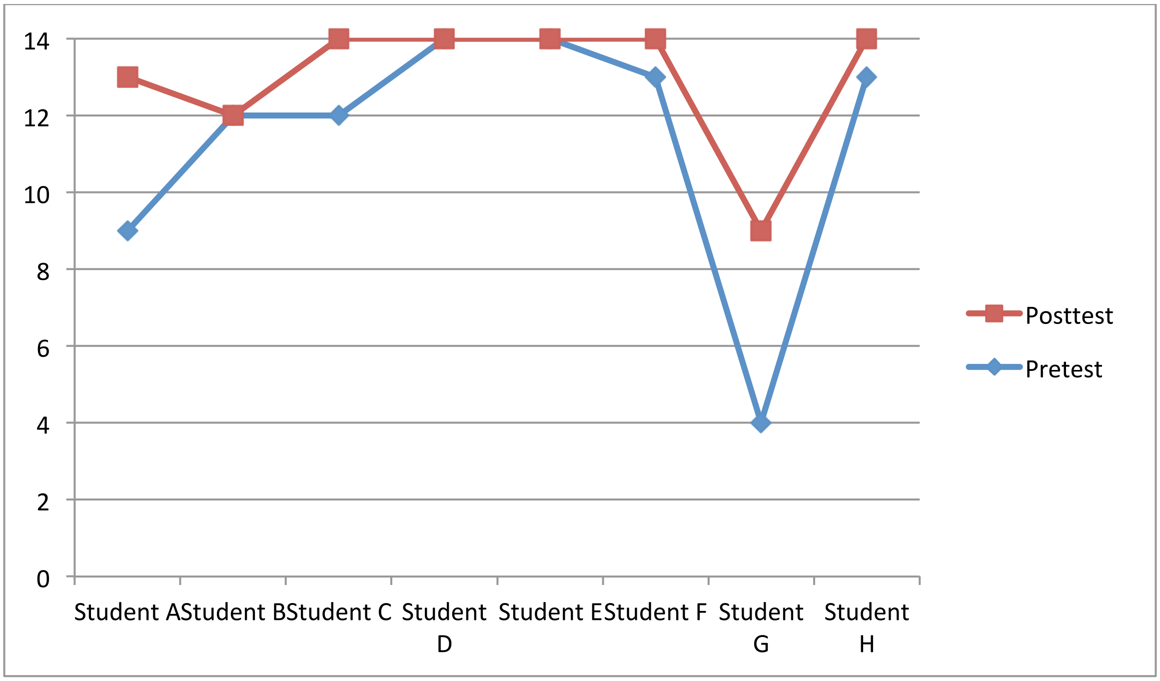
The shape personification provides interest and perspective. Students were eager to create their own brother triangle stories and incorporate the terms flip, turn, and rotation while identifying the vertices and degrees (more than or less than 90 degrees) of their classmate's shapes.

Session three and four allowed students to collaborate and create performances that applied foundational geometric concepts and vocabulary. Some of the ELL students stuck to the original story of brother triangle being disobedient when his mother was out (appendix B). Students adjusted their story to their entry level, Tomlinson & McTighe (2006) would describe starting point as readiness. In addition, interest and learning profile (p. 181) were included in the individual and group performances to make the experience differentiated based on rigor (level of creativity) and learning modalities; linguistic and verbal, logical/mathematical, visual/spatial, bodily or kinesthetic, reflection of self – intrapersonal, and working with others – interpersonal experiences.

Session five had participants draw a picture using only lines and angles. At this point in the session, many of the drawings told a story. It would have been interesting to compare the individual portfolio work prior to the lessons. Finally, session six included a post assessment on analytical seeing/visual problem solving and a written inventory of follow-up questions found on the end of unit assessment (appendix C).

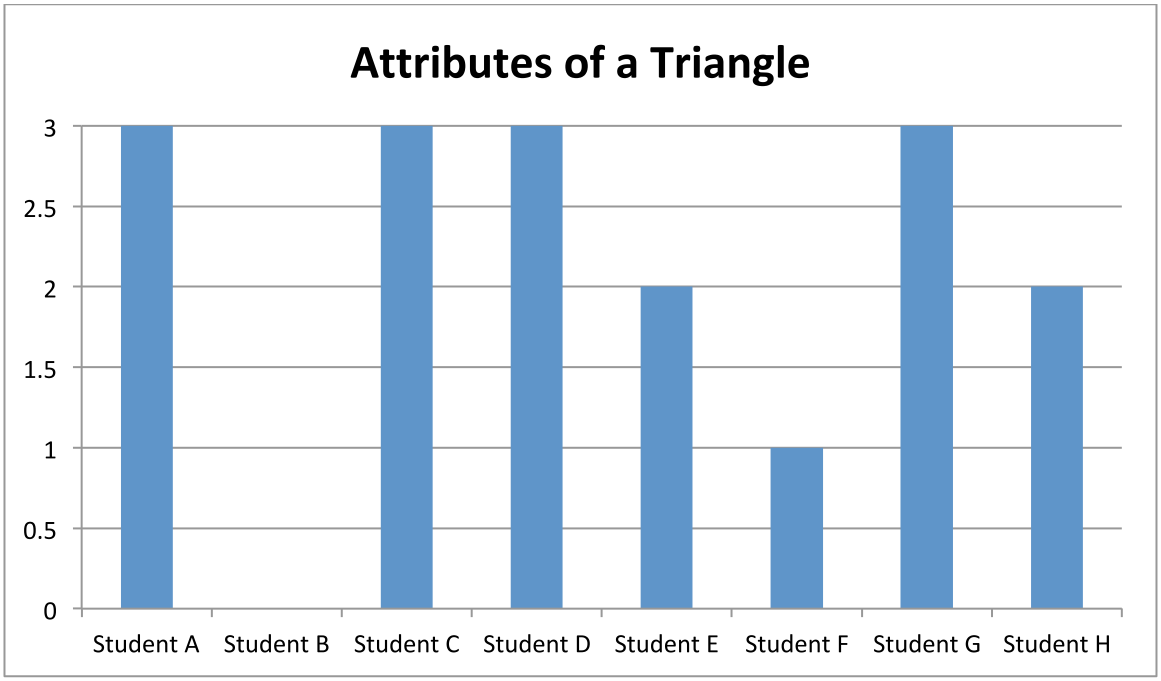
Data Analysis

The pre and posttest were measured based on the number of shapes correctly identified. Students applied knowledge of flips, turns, and rotations. The analytical seeing/visual problem solving inventory included 14 items. The class average on the pretest was 11.38 (see chart below). The class average on the post test was 13 out of 14. Three students saw no change, while student A showed a 29% gain and student G displayed a 35% gain.



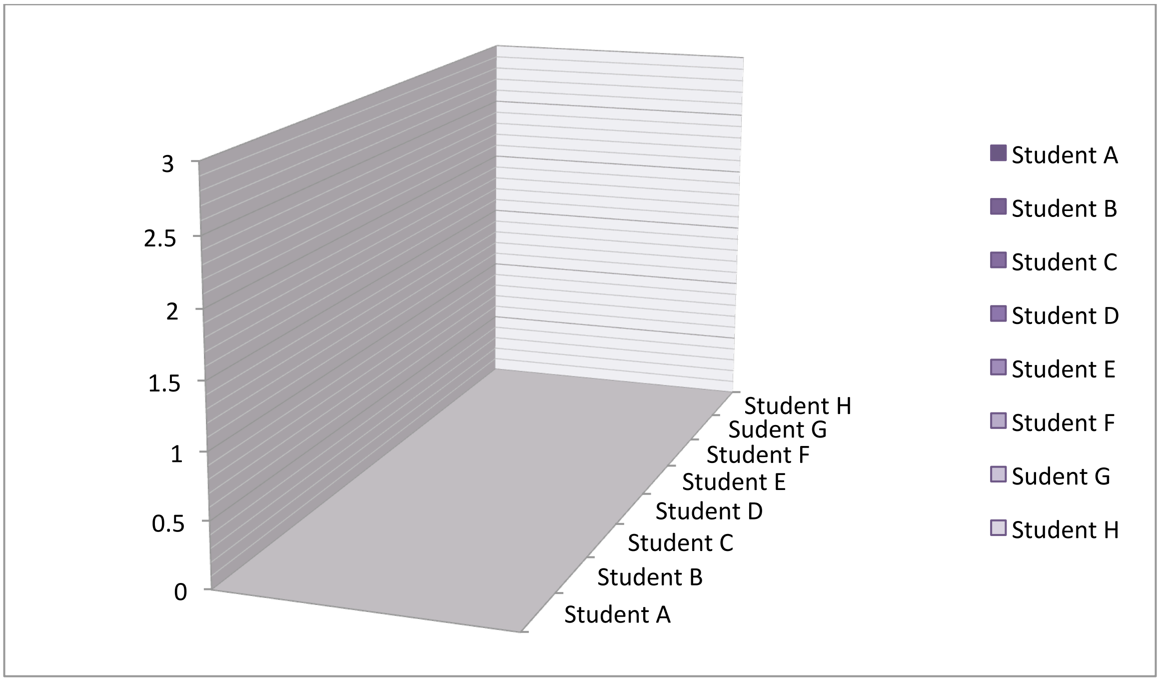
The pre and posttest show a gain in five of the eight students, no gain in three of the eight students, and no drop between the pre and posttest for any of the participants. Although the gains made by students A and G proved measureable, the pool of participants, and the number of items on the initial inventory is too narrow to measure a substantial increase in analytical seeing and visual problem solving.

In addition to the pre/post inventory, students completed a written assessment (appendix D) that included items similar to those found on the end of unit assessment for geometry. The students were measured on a 3 point rubric which measured; finding a triangle, identifying at least two attributes of a triangle, and listing at least one reason why the other shapes are not triangles. Students were then given a score of Meeting (3), Partially Meeting (2-1), and Not Meeting (0) the benchmark (see chart below).



The attributes of a triangle inventory was given at the end of the 6 week study. The focus paralleled the end of unit standard on geometry: reason with shapes and their attributes, and aligned with the Iowa Common Core (2012). The written assessment revealed that 4 of the participants scored at a level 3 (meeting standard), 3 participants scored at a level 1 or 2 (partially meeting standard), and 1 student scored at a 0 (not meeting standard).

Student B was unable to adequately answer the written response, but scored 12 out of 14 on the pre and posttest when assessing analytical seeing/visual problem solving. Student B had no English when he enrolled at Kittrell in the fall of 2012. When the assessment required a knowledge of shape orientation, student B had an 86% level of success, however when written language was expected, this student scored 0 out of 3. Both assessments measured knowledge of shapes and their attributes, however, the test that was language dependent displayed no knowledge of this standard. The data suggests that varied inventories and methods of assessment must be considered when making assumptions about conceptual knowledge when language is a barrier.



The eight students that participated in the 6 week study all scored between partially meeting (1-2) and meeting (3) the geometry standard: reason with shapes and their attributes. Seven weeks after completing the arts integrated lessons, all students maintained or increased their score on the end of unit assessment. Student B was able to successfully identify which of 4 shapes qualifies as a triangle, but was unable to verbally explain his thinking. The front loaded lessons proved to enhance the participant's geometric reasoning.

Implications

The results of this study suggest that arts integrated instruction enhances analytical seeing, geometry, and spatial reasoning. The participants were students that scored 0 (not meeting standard) on most of their end of unit assessments in math. Following the six hour sessions, seven out of eight students scored partially meeting (1-2) and meeting (3) on the written assessment. Seven weeks later the same participants all partially met or met the end of unit geometry standard: Reason with shapes and their attributes. The study concludes FLASH sessions that provide a varied modality to promote conceptual knowledge enhance student outcome in the area of geometry and spatial reasoning.

Half the participants were ELL students. Six of the eight students shared little to not at all during classroom discussions. Although I did not measure classroom participation, the classroom teachers commented that four of the reluctant speakers during math began sharing concepts about shapes, attributes, and orientation. Marcia Daft's arts integrated lessons, within Meet the Shape Family, provide specific math language. Based on an increase in classroom participation following the six week study, classroom teachers heard session-specific vocabulary transfer into the classroom discussion. Students began using math vocabulary, such as lines, angles, corners, vertices, 90 degrees, and flip.

Although the results of the analytical seeing/visual problem solving revealed major growth for two, some participants started high when identifying shape orientation and maintained their pre score on the post inventory. One recommendation would be to include more items on the pre-posttest that vary in complexity. Although two of the shapes were less obvious to "see" most of the shapes were less than a quarter turn of the original shape.

In conclusion, when supplementing the core, arts integrated lessons provide a varied modality which supports subgroups that struggle with conventional math tools. The bands provide a full body representation that enables the participant to apply what they feel about the shape. Marcia Daft's lessons provide a varied modality that addresses the kinesthetic learner while integrating rhythm, movement, and creativity. It is essential to consider vocabulary, creativity, and varied modality when supplementing a conceptual approach to geometry.

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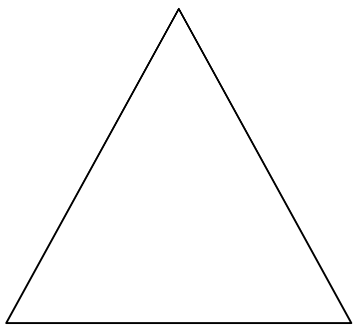
Appendix A

"We have met the lines, now we will meet Brother Triangle. Watch how I draw him on the board. First I draw one line lying down (horizontal). This line is his flat bottom. Then I draw two lines that look like slides (diagonal). These two lines connect at the top to make a corner (vertex). This corner at the top is Brother Triangle's pointy little head."



Note: Brother Triangle is an equilateral triangle

"When Brother Triangle is very polite, he sits on his flat bottom."

"This is good manners for a shape! Has your mother ever asked you to sit politely on your bottom?"

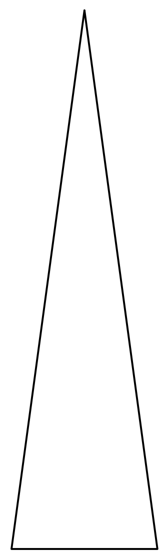
"Aisha, please come to the board and trace Brother Triangle's lines and tap his corners."

"Let's use the bands to show how three lines get together to make Brother Triangle."

Appendix B

“Look what happens to Brother Triangle’s bottom when he doesn’t eat the healthy foods his mother cooks for him.”

“His bottom gets too skinny! And the corner with his pointy little head gets strangely small!”



Note: This is an acute triangle. Side-angle relationships in geometry state that the smallest angle is always opposite the smallest side. The narrower the base (his bottom), the more acute the angle at the top (his head).

Page 19, Marcia Daft 2006, www.marciadaft.com

Appendix C

Name________________________________ Date____________________________________

Circle the shapes below that are triangles. For each triangle that you circled, list at least two reasons why it is a triangle. List at least one reason why the others are not triangles.