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INCREASING COMMUNICATION IN GEOMETRY BY USING A PERSONAL MATH CONCEPT CHART

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ABSTRACT

The action research team developed a "Personal Math Concept Chart". This chart required students to describe the mathematical concepts that they were studying in the Geometry strand of Mathematics using their own images and words. In this study, students were encouraged to express their own understanding of geometric concepts in order to strengthen their own personal knowledge. The purpose of the Personal Math Concept Chart was to enhance students' ability to express themselves using mathematical terminology. As part of having students work toward improving their mathematical expression with the Personal Math Concept Chart, the teachers on this action research team invited students to connect the concepts learned in class to everyday applications.

DESCRIPTION OF TEAM

The research team consisted of four teachers, Gety Kazerouni (Grade 1), Rhonda Friedman (Grade 1-2), Elli Weisdorf (Grade 3), and Stacey Lax (Grade 6) working at a school in a large, multicultural public district school board in south-central Ontario. During the 2008-2009 school year, this team took part in the Elementary Teachers' Federation of Ontario (ETFO) action research project entitled *Teachers Learning Together*.

Research Question*:* How does the use of a Personal Math Concept Chart affect students' communication in geometry?

Project Rationale*:* Communication in mathematics requires that students learn the language related to the mathematical concepts that they are learning. This knowledge can enable them to construct an understanding of concepts by having to explain them. This action research team began with the belief that the formulation of mathematical definitions and generalizations had the potential to strengthen students' ability to use clear mathematical language. The increasing number of English Language Learners (ELL) in Ontario schools demonstrates the need to recognize that students can face many challenges and subsequent difficulties with mathematical language/terminology. Understanding mathematical language, which includes being able to communicate clearly, facilitates understanding of mathematical concepts. This is a particular need for ELL students. In accordance with this research team's school board focus on literacy and "linking literacy across the curriculum," the team believed that students' understanding of geometric concepts and use of vocabulary would increase through the use of a Personal Math Concept Chart (Appendix A).

Putting mathematical ideas and reasoning into words is a key element of mathematical literacy. For students to become literate in mathematics, knowledge and understanding of vocabulary is essential. Good teaching practice includes educating students with applicable mathematical vocabulary (Paterson, 2007). As revealed by Bahr (1997), students in North America have a significant misunderstanding of mathematical concepts. As a result of these problems, the need exists to reshape our teaching practices of mathematics through the specific teaching of mathematical vocabulary. Therefore, it is important for mathematical literacy to include mathematical language.

Mathematical language and literacy can be taught through the use of graphic organizers. To reinforce students' conceptual understanding of specific concepts, such organizers can enhance the learning of specific vocabulary (Monroe, 1997). The consolidation of language can be attained through the use of both organizers and open-ended learning tasks. Sullivan, Mousley and Zevenbergen (2005) argued that open-ended learning tasks facilitate learning for students at all levels of achievement and they encourage specific teaching of vocabulary to help build students' understanding. Open-ended questions elicit both discussion and investigation. In her study of teaching math conceptually, Town (2007) stressed the importance of students making their own discoveries while extending their application of knowledge to new ideas. The encouragement of independent thinkers leads to the application of concept attainment. Students who devise their own procedures by making connections between mathematical language and their application to the real-world are able to foster greater mathematical literacy (Bahr, 1997).

PROJECT OVERVIEW

Process: This action research team from south-central Ontario consisted of four teachers that represented the three elementary divisions; this collaboration enabled the team to collect and analyze data representing a range of student ages. This team focused on two Grade 1 classes, one Grade 2 class, one Grade 3 class, and one Grade 6 class. Each member of the action research team performed a pre-assessment with her class. The students in Grades 1 and 2 had to identify 2-dimensional shapes on a worksheet. Students in Grades 3 and 6 were asked to study a picture in the *Mathematics Makes Sense* textbook (Morrow et al., 2004) and to describe and identify the shapes they saw using mathematical language. Each member of the action research team taught the Geometry unit using the *Mathematics Makes Sense* (Morrow et al.) textbook for her grade level to guide her teaching. In addition to the textbook, students used a Personal Math Concept Chart created by the research team.

This Personal Math Concept Chart was used to enhance student learning and reinforce specific vocabulary for the unit. Students in younger grades were guided by their teacher to complete the concept chart template according to their individual learning needs. Students in older grades were allowed more independence, but still had teacher support in completing their definitions of concepts. All students were guided using differentiated instruction, such as giving opportunities for students to answer in written form, verbally and using their own examples to illustrate concepts. To further differentiate, the team enabled students to represent their learning through visuals in addition to words.

As a post-assessment, students in Grades 1 and 2 were asked to pick one object of their choice (e.g., a rocket ship) and create that shape from pre-cut shape templates (Morrow et al., 2004). Upon completion, students were requested to use their geometric vocabulary to describe their picture. The students in Grades 3 and 6 were provided the same picture (as in their pre-assessment) and were asked to describe it, using their geometric language; this was to determine the impact the Personal Math Concept Chart had on their language development. All post-assessment tasks were evaluated using a rubric (Appendix D). Lastly, a survey was completed asking students whether they found the Personal Math Concept Chart to be beneficial to their learning (Appendix B). This action research study lasted approximately four weeks.

Data Collection: The data collection for this action research study took many forms. The team collected the pre-assessments that were conducted for each grade, including the pictorial descriptions. The team also used the students' Personal Math Concept Charts (Appendix A) which were completed during the teaching of the unit. Completed post-assessment tasks in which students had to use their geometric vocabulary (Appendix C) to describe pictures were collected in order to determine the impact the concept chart had on mathematical language development. The action research team also conducted math surveys to determine whether students found their Personal Math Concept Chart beneficial to their learning (Appendix B). In addition, informal math dialogue in class was noted anecdotally by each teacher, including the frequency of specific vocabulary used.

DATA ANALYSIS AND FINDINGS

Through this action research team's qualitative analysis, we explored the data to determine the impact that the Personal Math Concept Chart had on students' mathematical language development. Each member of this action research team examined a sample of her class' pre-assessments prior to teaching the Geometry unit, in order to check which concepts and vocabulary students were familiar with. After teaching the unit and using the Personal Math Concept Chart, each class was given a post-assessment task so that the results could be compared. The samples of students' post-assessment tasks were compared to their respective pre-assessments in the areas of use of concept chart vocabulary, length of answers, and clarity of descriptions. Student survey results were considered based on student self-reflection. As observed during class, informal math dialogue was noted anecdotally.

The team discovered that the majority of students were able to express their knowledge in a more specific way using the terminology from the Personal Math Concept Chart. All answers were longer, more descriptive, and students were able to describe the pictures with more clarity than in the pre-assessments. Student post-assessment answers included more relevant mathematical terminology as compared to the pre-assessment. Discussions overheard in class included a greater amount of mathematical language, in addition to more accurate use of such terminology. All four members of this action research team found that the quality and depth of math discussion in class was increased throughout the duration of the unit, using the Personal Math Concept Charts.

The students' response to the survey question of whether or not they found the concept chart *helpful in their daily work* was evenly spread between "always" and "sometimes." When asked to elaborate, students stated that the concept chart was useful in their daily work. Many students stated that "sometimes" *the chart was easy to use.* This feedback supports the belief that there were too many words for students to retain. With respect to *liking having a concept chart available for reference*, the majority of students surveyed replied that they "always" liked having the chart. Also in support of the concept chart, "most" students revealed that they *would like to have my personal math concept chart for all math ideas.* This feedback, from the survey, supports the use of the Personal Math Concept Chart in all strands, in addition to its effectiveness to student learning.

IMPACT AND IMPLICATIONS

The greatest impact that was identified throughout the implementation of the Personal Math Concept Chart, within all four classrooms, was the increase of math talk. Conversations between teacher and student, and student and student were enhanced through the use of the Personal Math Concept Chart. As a graphic organizer, this concept chart is a tool to good teaching practice which supports the findings from Monroe (1997). In addition, when students are able to link mathematical language to real-world applications, there is an increase in mathematical literacy (Bahr, 1997). Throughout this action research, teachers observed an increase in student dialogue, specifically in the chart sections entitled *Where We See It in the Real World*, and *What It Is Not*. For example, a key teachable moment arose in the Grade 2 classroom, when students were discussing *where they see* triangles *in real life*. They realized that the front face of a roof of a house was a triangle and a pizza slice was not a triangle but in fact a 3-dimensional solid. Likewise, students in grade 6 were required to use vocabulary pertaining to quadrilateral attributes and apply them to their classification activity. Being able to identify *what it is not* allowed students to sort quadrilaterals into Venn Diagrams. Overall, student math talk was enhanced through the use of the Personal Math Concept Chart in all classrooms because students began to question their own ideas and understanding of concepts. Another effect of the Personal Math Concept Chart was on the students' ability to increase their written math language. As evidenced, correct math terminology and more detailed answers suggested a positive impact on student learning.

In the post-assessment, the increase of math language suggested that student learning improved in the area of conceptual understanding and vocabulary acquisition. However, student learning was also fostered through the identification of student misconceptions which became a key component of the team's pedagogical discourse. One difficulty encountered by all students was the challenge in identifying the differences between 2-dimensional and 3-dimensional shapes, due to the fact that we live in a 3-dimensional world. Although this presented as a problem, student talk increased because they were compelled to examine the faces of a 3-dimensional object and compare them to the object in its entirety. For example, when trying to identify a circle, students in Grade 1 pointed to the clock, not realizing that a clock is 3-dimensional. Conversation then centred on the fact that the face of a clock is a 2-dimensional circle, while the entire clock is a 3-dimensional cylinder. Although this concept was not intended in the work of the action research team, it became a teachable component.

The Personal Math Concept Chart was a useful tool to introduce 2- and 3-dimensional shapes, as well as an encouragement to conversation. An observed implication to student learning was the decrease in the use of the Personal Math Concept Chart as the unit progressed. Students often needed a reminder to use the concept chart so that it would be an effective tool to their language development. Although students found the Personal Math Concept Chart beneficial, it was not second nature for the students to use it consistently.

The members of the action research team in both Grades 1 and 2 found the Personal Math Concept Chart beneficial in its initial stages. However, as the unit progressed, unless the students were reminded to use the chart, they would not take the initiative to use the chart independently. In the future, the teacher members of the action research team would modify this strategy by having a class-posted Personal Math Concept Chart and/or have a hand-held flip chart at students' tables, so that the terminology would be more accessible.

A challenge encountered by the students in Grades 3 and 6 was the number of words included for study within the Personal Concept Chart. Although all words were necessary for student understanding, the number of words as noted by the respective teachers of this action research team was overwhelming. While listening to student conversations, the frequency of specific words was noted. For example, in Grade 6, although students understood concave and convex polygons due to the concept chart, they rarely used this terminology when classifying quadrilaterals. Consequently, if the Personal Concept Chart was implemented again, in any subject area, a limitation to the quantity of words would be beneficial so students could focus on fewer concepts so as to deepen their understanding, and use them consistently.

The members of this action research team would suggest further inquiry into the application of a Personal Concept Chart to other subject areas. Based on students' responses from the survey that they "always" *liked having a concept chart for reference,* the research team concluded that the chart was both useful and valuable. To enhance learning in all subject areas, the concept chart can be implemented to expand student vocabulary. Likewise, the chart would benefit both special education and ELL students, to further their vocabulary and subsequent learning. The chart could also be completed in the students' first language.

One question the members of this action research team considered was related to the usefulness of the Personal Math Concept Chart in the other four strands of mathematics. This team would like to explore how the chart would further students' mathematical language in other math strands. Likewise, the question can be raised as to the usefulness of the Personal Concept Chart in other curriculum areas. An alternate study could focus on the comparison of teaching the same math unit to multiple classes, varying the use of the Personal Math Concept Chart. The data collected from this particular study could indicate whether it is the Personal Math Concept Chart that aids students' language development or the exposure to the language within the unit itself.

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BIOGRAPHICAL NOTE:

Rhonda Friedman is currently teaching a Grade 1-2 split class at Thornhill Public School in the York Region District School Board in southern Ontario. Since Literacy is a focus in York Region, Rhonda feels it is important to incorporate literacy into studies in the area of Mathematics. Rhonda can be contacted through the York Region District School Board site.

Gety Kazerouni is currently teaching an Autism Spectrum Disorder (ASD) Community Class at Thornhill Public School. This school is located in the York Region District School Board, in southern Ontario. Since she began teaching in this specialized area, her curriculum planning has featured a strong emphasis on following a functional program that includes mathematical literacy. Gety can be reached through the York Region District School Board site.

Stacey Lax is a practicing teacher in the York Region District School Board, in southern Ontario. Currently, Stacey is teaching Intermediate math to students in Grades 6, 7 and 8 at Thornhill Public School. Her interests include integrating literacy into mathematics and incorporating math conversation into everyday language. Stacey can be reached through the York Region District School Board site.

Elli Weisdorf is a practicing teacher in the York Region District School Board, in southern Ontario. Currently, Elli is teaching Grade 4 at Bayview Hill Elementary School in Richmond Hill, Ontario, where she is incorporating literacy into her teaching of mathematics and coordinating an extra-curricular Math Club for students in Grades 4 and 5. Elli can be reached by email at: elli.weisdorf@yrdsb.edu.on.ca

APPENDIX A: Personal Math Concept Chart Template (Action Research 2008-09)

Category	Word	Picture	Description	Where we SEE it in Real-Life	What it is NOT

APPENDIX B: Geometric Math Survey (Action Research 2008-09)

Name _________________

1. I used my personal math concept chart.	always	sometimes	never
2. The personal math concept chart was helpful in my daily work.	always	sometimes	never
3. I used my personal math concept chart on a daily basis.	always	sometimes	never
4. My personal math concept chart was easy to use.	always	sometimes	never
5. I understood the words in my personal math concept chart.	always	sometimes	never
6. I liked having my personal math concept chart for reference.	always	sometimes	never
7. My personal math concept chart helped me to explain myself.	always	sometimes	never
8. I was able to make sense out of my personal math concept chart.	always	sometimes	never
9. I can use the words in my personal math concept chart.	always	sometimes	never
10. I would like to have my personal math concept chart for ALL math ideas.	always	sometimes	never

APPENDIX C: Grade Specific Word List for Concept Chart (Action Research 2008-09)

Word	Grade 1	Grade 2	Grade 3	Grade 6
polygon		*	*	*
quadrilateral		*	*	*
prism			*	*
pyramid			*	*
square	*	*	*	*
rectangle	*	*	*	*
circle	*	*	*	*
triangle (6)	*	*	*	*
rhombus	*	*	*	*
parallelogram			*	*
trapezoid			*	*
octagon		*	*	*
pentagon		*	*	*
hexagon		*	*	*
heptagon		*	*	*
edge			*	*
face			*	*
vertex			*	*
angle			*	*
right angle			*	*
cylinder			*	*
parallel			*	*
symmetry				*
rotational symmetry				*
translation				*
transformation				*
reflection				*
rotation				*

APPENDIX D

GEOMETRY RUBRIC

Categories/Qualifiers	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
KNOWLEDGE -Of content: proper use of terminology	Demonstrates limited knowledge of content	Demonstrates some knowledge of content	Demonstrates considerable knowledge of content	Demonstrates thorough knowledge of content
THINKING -Making a plan: organization; interpreting problem	Uses planning skills with limited effectiveness	Uses planning skills with some effectiveness	Uses planning skills with considerable effectiveness	Uses planning skills with a high degree of effectiveness
-Use of processing skills: modeling; solving; analyzing; forming conclusions	Uses processing skills with limited effectiveness	Uses processing skills with some effectiveness	Uses processing skills with considerable effectiveness	Uses processing skills with a high degree of effectiveness
COMMUNICATION -Expression and organization of mathematical ideas: oral, visual, written forms	Expresses and organizes ideas with limited effectiveness	Expresses and organizes ideas with some effectiveness	Expresses and organizes ideas with considerable effectiveness	Expresses and organizes ideas with a high degree of effectiveness
-Use of conventions: vocabulary & terminology in oral, visual and written forms	Uses conventions, vocabulary & terminology with limited effectiveness	Uses conventions, vocabulary & terminology with some effectiveness	Uses conventions, vocabulary & terminology with considerable effectiveness	Uses conventions, vocabulary & terminology with a high degree of effectiveness
APPLICATION -Transfer of knowledge and skills to new context	Applies knowledge and skills in familiar contexts with limited effectiveness	Applies knowledge and skills in familiar contexts with some effectiveness	Applies knowledge and skills in familiar contexts with considerable effectiveness	Applies knowledge and skills in familiar contexts with a high degree of effectiveness
-Making connections within and between various contexts	Making connections within and between various contexts with limited effectiveness	Making connections within and between various contexts with some effectiveness	Making connections within and between various contexts with considerable effectiveness	Making connections within and between various contexts with a high degree of effectiveness