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The Importance of Vocabulary Instruction in Everyday Mathematics

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Abstract

In this action research study of my 6th grade math students I try to answer the question of how mathematical vocabulary plays an integral role in the understanding and learning of middle level mathematics. It is my belief that mathematics is a language, and to be fluent in that language one must be able to use and understand vocabulary. With the use of vocabulary quizzes and mathematically-centered vocabulary activities, student scores and understanding of math concepts can be increased. I discovered that many of the students had never been exposed to consistent mathematical terminology in their elementary education, which led many to an unfavorable impression of math. As a result of my research, I plan to incorporate vocabulary as a regular part of my mathematical teaching. As the students understood the language of math, their confidence, attitudes, and scores all began to improve.

My research topic is the use of mathematical vocabulary and its implications in the classroom, namely improving understanding and scores. To better understand math one cannot survive on numbers alone; there has to be meaning and reason that goes along with the calculations and formulas. Mathematics is a language that is written using numbers and symbols that can often confuse those who do not understand its detail and intricacies. I feel that if students can put "a name with a face", so to speak, they can start to really understand and translate mathematical terminology into useful knowledge on their daily assignments. This then would correlate into better attitudes towards math as well as better scores.

My path towards this specific topic started a long time ago when I was a student myself. I was an average student who did okay in math class. As I got older and the classes became more challenging, I started to struggle more and more. I had a hard time understanding my assignments, or even the directions, and my teachers were using words that were unfamiliar to me. I would miss problems not because I did not know how to do them, but because I did not understand the words that were being used. For example if the book said "list the first seven multiples of five", "multiples" was a word that was unclear to me. I understood how to count by fives but did not make the connection that it was the same thing. I began to see how this type of confusion could cause big problems down the road, not just for me, but for others as well.

Now that I am a teacher of mathematics I wonder how many of my students encounter this same type of problem. Since many of our elementary teachers use different terminology to explain math, there isn't a consistent uniform version of math vocabulary in our district. When the students come to sixth grade from elementary we as 6^{th} grade teachers need to get everyone on the same page. Better yet, perhaps our district math teachers need to use a consistent

vocabulary to ensure that everyone starts out on the same page and continues it through to high school.

Problem Statement

I believe that the importance of vocabulary in a math classroom is vital if a student is truly going to understand the concepts being taught. If students had a better background knowledge of math terminology, more teachers would see positive results in their students' work and grades. An athlete and a coach cannot be successful if the athlete has no idea what the coach is saying. If a soccer player is told to "make an early run so that you can receive the overlap and then get the cross off to the striker at the near post" and has no idea what that means, he/she will undoubtedly not get the job done.

A major problem I have seen, and one which colleagues have also witnessed over the years, is the inability of students to recognize and recall math terms. This is important because when it is time to test, many students miss problems not because they do not know how to do the work, but rather they do not understand what it is they are supposed to do. If students could utilize and recall math terminology and its relevance on a daily basis, test scores as well as grades would improve. How can a student are expected to find the greatest common factor of two numbers if he/she has no idea what a factor is? He/she may get by for the day, but when that same problem appears later and the word factor still has no meaning, the student will inevitably have learned nothing.

Literature Review

Although there is not a lot of information on the specific topic of mathematical vocabulary, there is evidence that others feel the value in its presence within the math classroom. Harmon, Hedrick and Wood (2005) provided research in the area of content vocabulary and the

role it plays within a mathematical classroom setting. Their work provides understanding that influences learning across different disciplines. “In content area reading, students need a thorough understanding of vocabulary because the words are labels for important concepts” (Harmon, Hedrick, Wood, 2005, p. 265). To be a good math student one needs to be able to read mathematics, and more importantly, understand what he/she is reading. However, since many students do not possess a good math vocabulary, they have difficulty reading and understanding mathematical content. “Mathematics presents challenging reading because this content area has more concepts per word, per sentence, and per paragraph than any other area” (Harmon, Hedrick, & Wood, 2005, p. 266).

Knowing that, why has there not been more teaching of vocabulary-related content within the math classroom? At least one pair has explored this topic. Working with high school math students, Fletcher and Santoli (2003) explored mathematical vocabulary and how to implement it into a mainstream classroom. They found that using proper math terminology regularly helps students to better comprehend mathematical concepts. According to Fletcher and Santoli (2003) “The vocabulary of mathematics is not usually taught in schools. If students are not reading good textbooks, then they have no place to read terms” (p. 6). Do students believe it would be beneficial for them if they had a greater understanding of mathematical terminology? In my research only 27% of my sample group said that they had been taught math words from their elementary teachers. Yet 82% of the same group said that they believed math class would be easier if they knew the meanings of more mathematical vocabulary. In an interview one student explained why it is of value to know the vocabulary. “Because then you understand the problem, and you can get a better picture of what they’re asking you to do” (Student Interview, March 2007).

Equally important is making sure that the students understand the context in which the math terminology is being used. Even when students come across "familiar" words in their mathematics class they soon find out that what they first thought was the definition of the word is not always what the math definition turns out to be. Orme and Monroe (2002) discuss in their research the importance of vocabulary and how it affects learning. They note that proper vocabulary is critical to any experience involving language. "Many terms have meanings in the realm of mathematics that differ from their meanings in everyday usage" (Orme & Monroe, 2002, p. 140). I have had some of my students get confused when I ask for the product of two numbers because their first impression of a product is something that you buy from a store, not two numbers that are multiplied together.

Purpose Statement

The purpose of my study is to show that incorporating a math-related vocabulary curriculum will help students to better understand math concepts. With better understanding comes better grades and improved test scores. I want to explore the following questions:

1) Will giving vocabulary quizzes help to improve students' understanding of math concepts and improve test scores?
2) Will giving a daily vocabulary word and having the students use it in a mathematical context improve understanding of its meaning?
3) Can vocabulary-based math games and activities improve students' comprehension of mathematical vocabulary and terminology?

As I teach math I find that many students approach math as a numbers only class. Students see no need to remember definitions or vocabulary words or the context in which they are used.

"After all, this isn't Language Arts class, right?" Mathematics is a language, and for one to understand the language one must be able to speak the language correctly.

I want to know if doing a little bit of vocabulary each day will trigger some retention in the math concepts that we are currently studying. If we can put meaning to the words that the students are seeing in their math books and in their assignments, perhaps they can better understand what it is they are supposed to do on their assignments. I also want to find out whether weekly vocabulary quizzes along with specifically designed vocabulary activities can expose students to current grade level terms that might help them make connections to past, present, and future mathematical concepts.

Method

To start my research I first developed a list of vocabulary words that I thought was appropriate for the sixth grade level. I went through my textbook and selected words that were used frequently and had great significance in the assignments the students would be doing. I compiled these words (see Appendix A) into a list that I then gave to the students to be put into their vocabulary folders that we would be creating throughout the duration of my research. Into these folders would go anything that was vocabulary related, including the weekly quizzes, vocabulary activities, notes, and other items. The vocabulary activities that were done during my research were meant to be fun activities that were not viewed as typical schoolwork. I wanted the students to use the words from the list over and over each week to attain comprehension without actually sitting down and studying them in the traditional sense. Examples of student activities include creating their own word search puzzle for other students to solve and coding various vocabulary definitions using a cipher wheel and then having a partner decode the definition to

discover the actual word. We also created pictures using only vocabulary words. During this activity the students were not allowed to draw lines in the typical art sense.

In addition to the vocabulary folders, I wanted the students to write down at least one definition each time they worked on a daily assignment. At the beginning of each assignment in our textbook there is a section that lists the key words being used for that particular concept. The students, as part of their daily grade, were to pick one of these words and write the definition at the top of their paper. This then would hopefully make them aware of the key word and its application to their daily assignment. Students were also asked to read through the vocabulary list of words at least once if they finished their daily assignment early.

Another component was our weekly vocabulary quiz that was taken at the end of each week. To select each week's eight words I would randomly select them using my TI-84 calculator; all words were fair game for each quiz. I wanted the selection to be random so that the students could not study a specific group of words and neglect the remaining words from the list. To help remember the words that were on their vocabulary lists, the students were allowed to use a word bank (see Appendix B) during the quizzes. After each quiz had been graded each student recorded his/her score on a graph chart (see Appendix C) so that he/she could track his/her progress throughout the course of the quizzes.

Finally, the last part of my research was to see if vocabulary would help students on their standardized tests. To do this I gathered math test scores from the Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAPS) test which was given to our students in the fall of 2006 and the spring of 2007. The test measures students on math, language arts, reading, and science. In addition the test acclimates to each student's ability by constantly adjusting the difficulty level of each question based on the previous question's response. I then

compared the fall test to the spring test to see how much the students had improved over the course of the school year.

I surveyed my students on math-related issues concerning vocabulary and its impact on the student's perception of math and its involvement in how they work and solve math problems. The survey was given at the beginning of my research around the end of February 2007. I wanted to get opinions from the students on topics such as how much they like math, whether they think they are good at math, how comfortable they are with vocabulary in general, and more specifically mathematical vocabulary. Students were asked to circle a number between 1 and 5, with 1 being the lowest, and 5 being the highest, on how much they agree with each survey statement. I also included five questions on what the student liked and disliked about mathematics in general.

I then conducted interviews with 19 of my students during the course of my research. Each student was only interviewed once, and the interviews were conducted in my classroom when time permitted for the students and me. Interviews were generally brief but gave a good insight to each student's views on their progression through their mathematical year as well as their progression through the research project. Questions centered on mathematical background, good versus bad experiences in math, previous teachers and their teaching methods, and whether or not they felt vocabulary was an important part of learning mathematics.

Findings

At the beginning of my research I handed out a survey (Appendix D) to get a feel for the students' perception of math and the role that vocabulary plays in understanding mathematics. Of the 14 students who completed the survey, 9 or 64% recorded a 3 or lower out of a possible 5 when asked if they were good at math. Many during the interview session cited that they simply

do not understand what they are supposed to do on assignments; “It is difficult when I do not understand the problems” (Student Interview, March 2007). Another was more specific with her explanation. “In math I think word problems are the most difficult for me” (Student Interview, March 2007). It is again noteworthy to point out that only 27% of those interviewed said that their elementary teacher had gone over mathematical vocabulary with them when they were younger. 82% did think that knowing vocabulary would make math easier. When asked why, one girl responded by saying “Knowing the meaning of a vocabulary word is easier, and you understand it (the problem) better” (Student Interview, March 2007). Another said, “If you do not know something, vocabulary can help you explain” (Student Interview, March 2007).

One of my primary questions at the beginning of my research was to see if giving weekly vocabulary quizzes would help to improve students’ understanding of math concepts. I believe that exposing the students to the vocabulary will help to make them more aware of the words they see in their daily assignments which will then translate to higher vocabulary scores as well as test scores. Over the course of the research seven vocabulary quizzes were given, one per week with the initial quiz being a pre-quiz that the students did before being exposed to the vocabulary list. During the pre-quiz the average score was 2.3 correct answers out of 8. With each consecutive quiz the scores continued to increase as follows; 3.9, 4.1, 4.6, and 6.2. The average score of 6.2 out of 8 was the peak of the quizzes, with the last two quizzes taking a dip to 3.7 and finally 4.7 for the last quiz. Since the vocabulary list consisted of 60 plus words, with which many of the students were unfamiliar, they did a good job after the initial pre-quiz to get at least 50% of the words correct on all the remaining quizzes.

The standardized test that I used for this project was the NWEA Maps test that is given annually in the fall and again in the spring. The fall mean score for the entire sixth grade was

217, and the spring score had a mean of 225. The range of scores for this test fell between 161 and 250 with possible scores going below 161 and above 250. The higher the score the better the student did on the test. Test scores are then compared with other students around the country who also take the NWEA Maps test. In comparison my students who participated in this research study started out in the fall with a mean score of 216 and ended the spring test with a mean score of 224. It appears that they grew as expected along with their sixth grade counterparts. However, when the growth between tests is examined it is clear that the students who did the vocabulary work grew more than those who did not participate in the vocabulary exercises. This growth is evident by the increase in the students' score from the fall test to their score on the spring test. The average growth for the sixth grade was 7.5 points per student, while the average growth for my study group was 10 points per student. In addition, all but two students had positive growth scores. Many of the students expressed that they thought they did better on the test the second time because they understood more of the terms used in the questions written on the test.

My second area of concern was whether using a daily vocabulary word from the daily lesson would help to improve the students' understanding of the math concept. Using proper vocabulary in conjunction with its computational design builds retention. In addition to the standardized test scores going up, the students' math grades also seemed to be on the rise. I recorded grades for the students at the end of our third quarter, which was a few weeks after the introduction into the vocabulary unit. While engaged in the project, many of the students' daily assignments indicated that progress was being made toward better scores. Each daily assignment had to be turned in with at least one of the key vocabulary words defined across the top of the paper. Again, this was to reinforce the key word and the concept with which it relates. The mean score at the end of the third quarter was 82.5% in comparison to 87.3% at the end of the fourth

quarter. Of the students participating in the study all but two improved their scores from the third to fourth quarters. Those that did improve their scores did so by a mean of 6.3%. This was encouraging because during this time of the school year scores tend to drop a small amount with all the standardized testing that is taking place. Generally less time is spent on the daily assignments and more time is spent getting ready and reviewing.

The last portion of the research project was to have the students work with these vocabulary words in a project-based environment; I did not want them to sit down and memorize definitions via the rote method. I believe that if the activity is fun or engaging they will take the time to learn more words, thus building a bigger mathematical vocabulary. I wanted the students to work on fun, engaging activities that allowed them to express some creativity while at the same time helped them to recognize and remember various vocabulary words and concepts with which they relate. Working on these weekly activities allowed the students to learn the vocabulary words without having to sit down and study them in the traditional sense. I knew the students were starting to understand the terminology when they started to correct me if I made a mistake while teaching or if I did not use the proper word in my explanation. One example is when we were discussing how to divide fractions. I told the students that they could “flip” the second fraction and then change the problem to multiplication to solve. A few curious looks were thrown my way before one student raised his hand and said, “Flipping...isn’t that the same as using the reciprocal?”

Often students would go above and beyond what I had assigned for the project. Students would frequently do more work than was needed. If I asked them to create a word search with 12 words, they would ask me if they could do 15 or even 20 words. One activity had the students coding vocabulary definitions with a cipher wheel and then having a partner try to figure out the

vocabulary word by decoding the information. I asked them to pick five definitions; many did seven to ten instead. They even wanted to take the assignment home and work on it for homework.

Conclusion

Based on my research I would definitely say that vocabulary plays a major part in the understanding of mathematical concepts. I would like to see how well the students could do with a full school year of mathematical vocabulary integrated into their regular math curriculum. In the relatively short time that this research project was done, daily assignment scores went up, and there was better than average growth on the standardized test. Once the students were more aware of the vocabulary they were using and how it played an integral role in their lessons, they started to comprehend the concepts better. I think it would be quite valuable for elementary teachers to start using proper mathematical vocabulary on a consistent basis so that children can ingrain these terms and meanings at a young age. Trying to catch them up in the middle school years can be a challenging task. “It is important to know which meaning of a word students are using when trying to make sense of mathematics because words used in everyday language may confuse their understanding of mathematics” (Adams, 2003, p. 788).

Implications

After the completion of my project, it is clear to me that I need to integrate a vocabulary-based curriculum into my classes for next year. As a student who struggled with math because of the confusion I faced with math terminology, I believe it is my responsibility to make sure that my students do not have to deal with those same difficulties. I think that vocabulary quizzes will be part of my weekly agenda, as will be periodic vocabulary-based assignments. Consistent reinforcement of math terms will have to be present in my teaching of math concepts throughout

the school year as well. Using proper terminology instead of convenient substitutes will train the students to speak the language of mathematics. “The understanding of mathematical words is fundamental to the development of sound concepts and mathematical thinking” (Raiker, 2002, p. 50). Students must learn that mathematics is more than just manipulating numbers to come up with an answer; it is indeed a language unto itself that must be learned with fluency before true comprehension can occur.

It is important to realize that attaining this goal cannot be done by one person alone. To truly be successful it must be a team effort among teachers, not only on the same grade level, but also between grade levels. Properly preparing the students we currently have will only help to benefit those students’ teachers next year, and the year after that, and so forth. Now I know that teacher’s time is very valuable, and it seems as if more and more things are constantly being added to the educational plate. However, taking just five minutes of class each day to discuss the vocabulary on the daily lesson will greatly pay off in the long run. That 25 minutes each week spent on honing proper vocabulary will start to show as the student’s school year and mathematical career progress.

Personally I plan to voice my concerns will my fellow math teachers when the next school year begins. I will be in the fortunate position of being a team leader which will give me the opportunity to be part of some changes that will be taking place at our school. I can share my experiences with my fellow teachers and guide them with any activities that they would like to try in their classes as well. Perhaps I can even give them a vocabulary activity to try with their students to get the ball rolling in the right direction. They just have to see that positive results can be achieved without spending large amounts of time away from the actual teaching of the

mathematical concepts. As students progress with these “baby step” vocabulary lessons, they will start to translate the concepts and “big ideas” into what we want our students to learn.

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Appendix A

6th Grade Vocabulary List

Angle	A figure formed by two lines (rays) with the same endpoint.
Area	The amount of surface covered by a figure.
Average	A single number used to describe what is typical.
Base	The repeated factor (The bottom number when using exponents.
Bias	Something that might prevent results from being representative of the truth.
Bisects	To cut something in half.
Capacity	The amount that a container can hold.
Circumference	The distance around a circle.
Compatible	Numbers that work with one another.
Composite	A number bigger than 1 that has factors other than itself and 1.
Congruent	Figures with the same size and shape.
Coordinate	The numbers in an ordered pair (X,Y) that locate a point on a grid.
Cube	A rectangular prism with 6 congruent square faces (e.g. dice).
Decimal	A number that is written using the base-ten place value system. Each place value is ten times the place value to the right.
Decrease	To make smaller.
Denominator	The number below the fraction bar in a fraction problem.
Diagonal	A segment, other than a side, that connects two vertices of a polygon.
Diameter	The distance across a circle through its center.
Difference	The result when one number is subtracted from another.
Digit	Any of the numbers 9, 8, 7, 6, 5, 4, 3, 2, 1, 0.
Dividend	A number that is divided by another number. The number in the box.
Divisible	A number is divisible by another number if that other number is a factor of the first (3X4=12, 12 is divisible by 3 & 4).
Divisor	The number by which another number is divided (The number on the outside of the box).
Edges	The line where 2 faces meet.

Elapsed time	The amount of time between a start time and an end time.
Equation	A mathematical sentence formed by placing an equal sign (=) between two expressions (3y=21, or X-3=7).
Equivalent	Equal to something else.
Estimate	To find an approximate solution to a problem.
Evaluate	To find the value of an expression (To solve a problem).
Even/odd	Even numbers end in 0, 2, 4, 6, or 8 and Odd numbers end in 1, 3, 5, 7, or 9.
Exponent	The exponent of a power is the number of times the factor is repeated.
Expression	An algebra problem (e.g. Solve the expression).
Faces	The polygons that form the solid figure.
Factor	When whole numbers other than zero are multiplied together, each number is a factor of the product (2X3x7=42; 2, 3, and 7 are factors of 42).
Formula	Steps to solving a particular problem.
Improper fraction	Any fraction in which the numerator is bigger than or equal to the bottom number.
Increase	To make bigger or larger.
Integers	The numbers …-5,-4,-3,-2,-1, 0, 1, 2, 3, 4, 5…
Intersection	Where two things meet (e.g. Two lines intersect at a point).
Mean	(Average) The sum of the data values divided by the number of values.
Mixed numbers	A whole number with a fraction next to it.
Multiple	A multiple of a whole number is the product of the number and any nonzero whole number (The multiples of 2 are 2, 4, 6, 8, 10, 12…).
Numerator	The top number in a fraction.
Ordered pair	Numbers that locate a point on a coordinate grid (e.g. (4, 3) or (34, 84) or (8, -2)).
Parallel	Lines in the same plane that never touch.
Percent	A ratio that compares a number to 100. Percent means "per hundred."
Perimeter	The distance around a figure.
Perpendicular	Two lines that meet to form a right angle, 90 degrees.
Polygon	A closed shape that is formed by 3 or more segments called sides.
Powers	An expression, such as 2^3, that represents a product with a repeated factor.

Prime	A whole number bigger than 1 whose only factors are 1 and itself (7 is prime because only 1X7 =7).
Prism	A solid with two parallel bases that are congruent polygons.
Probability	A measure of the likelihood that an event will happen, when all the outcomes are equally possible.
Product	The answer to a multiplication problem.
Pyramid	A structure that has triangles on the sides.
Quadrilateral	A four sided shape. "Quad" means four.
Quotient	The answer to a division problem.
Radius	The distance from the center of a circle to any point on the circle itself.
Remainder	The whole number left over after you finish a division problem.
Rotate	To turn something.
Segment	A part of a line that consists of two endpoints and all the points between them.
Simplify	Simplify.
Sphere	A 3 dimensional ball.
Sum	The answer to an addition problem.
Supplementary	Two angles that add up to 180 degrees. Each angle is a supplement.
Value	The amount something is worth.
Vertex	A point where 2 edges or 2 sides meet.
Volume	The amount something can hold.
Whole numbers	The numbers 0, 1, 2, 3, 4…

Appendix B

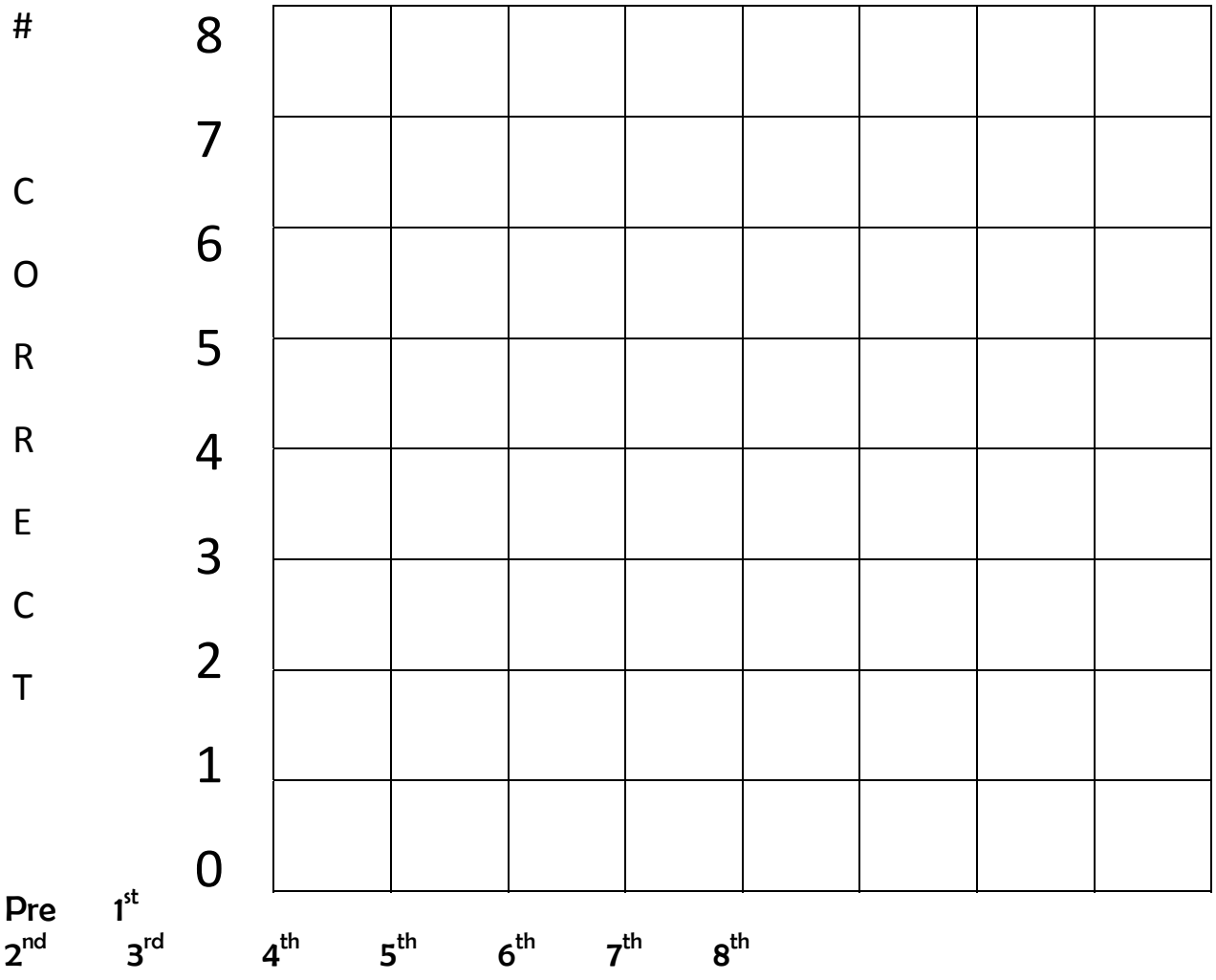
Word Bank

Angle
Area
Average
Base
Bias
Bisects
Capacity
Circumference
Compatible
Composite
Congruent
Coordinate
Cube
Decimal
Decrease
Denominator
Diagonal
Diameter
Difference
Digit
Dividend
Divisible
Divisor
Edges
Elapsed Time
Equation
Equivalent
Estimate
Evaluate
Even/Odd
Exponent
Expression
Faces
Factor
Formula
Improper Fraction
Increase
Integers
Intersection
Mean
Mixed Numbers
Multiple
Numerator
Ordered Pair
Parallel
Percent
Perimeter
Perpendicular
Polygon
Powers
Prime
Prism
Probability
Product
Pyramid
Quadrilateral
Quotient
Radius
Remainder
Rotate
Segment
Simplify
Sphere
Sum
Supplementary
Value
Vertex
Volume
Whole Numbers

Appendix C

Name_____

Student Chart



Appendix D

Math Survey

Give your honest response to each statement, 1 being the lowest, and 5 being the highest.

1. I like math. 1 2 3 4 5
2. I am good at math. 1 2 3 4 5
3. Math skills are important for other skills. 1 2 3 4 5
4. I am able to show the work required to solve math problems. 1 2 3 4 5
5. I like to answer questions asked in math class. 1 2 3 4 5
6. I feel comfortable asking questions in math if I do not understand a concept. 1 2 3 4 5
7. I am good with vocabulary. 1 2 3 4 5
8. I am good with mathematical vocabulary. 1 2 3 4 5
9. I am a good reader. 1 2 3 4 5
10. I understand many of the math words I see in my textbook. 1 2 3 4 5
11. I can read and understand the directions in my math textbook. 1 2 3 4 5
12. Math is useful outside of school. 1 2 3 4 5

Complete the following statements

1. Math would be easier if:

2. In math I am good at:

3. In math I am not so good at:

4. One thing I like about math is:

5. One thing I dislike about math is:

Appendix E

Student Interview Questions

1. How much time on average do you spend on homework assignments?

2. What do you think is the purpose of math homework?

3. What do you like best about math? What do you like least about math?

4. What makes math easy or difficult for you?

5. Have you ever had a really bad experience with math? If so, what happened?

6. What could teachers do to help students in math?

7. When working a word problem, do you think you know the meaning of most of the vocabulary words in each problem?

8. Why is it important to know the meanings of vocabulary words you see in math?

9. Did your math teachers in elementary school explain math vocabulary to you?

10. Have you ever tried to work a problem but did not understand the directions; however, once the vocabulary was explained to you, you then could work the problem correctly?

11. What helps you to remember the meaning of a vocabulary word?

12. Would math class be easier if you knew the meanings of more mathematical vocabulary words?