# Integrating Mathematics with Writing

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*Since the learner is actively engaged when composing writing assignments, integrating math through various writing modes can enhance and strengthen students' understanding of math concepts. Two expository writing assignments, an acrostic poem and a vocabulary activity, are demonstrated. Writing can have a positive effect on learning as students synthesize, analyze and evaluate course content in an organized schema. Assigning writing activities to mathematics students will encourage them to read their math textbook and other material such as math websites on the Internet in greater depth.*

Researchers in active learning strategies have focused on writing as "an essential activity to create order from chaos, sense from nonsense, meaning from confusion: as such it is the heart of creative learning in both the arts and sciences" (Blair, 2006, p. 54). Since the 1980's writing across the curriculum has been an outcome for many school programs not only to improve writing skills but also to improve students' understanding of content (Romberger, 2000). Writing-across-the-curriculum (WAC) programs have been steadily increasing. According to Panici and McKee (1997), "Forty-six percent of all Ph.D. granting institutions and 48 percent of all BA/MA granting institutions have a WAC program" (p. 47). These institutions have incorporated WAC programs on the basis that integrating writing supports and strengthens learning. As reported by Panici and McKee, research conducted by Barr indicates "the use of summary writing in a senior seminar in mathematics and computer science was beneficial for students in pulling together important ideas from their previous course work and in expanding their understanding of mathematics" (p. 47).

Studies have shown that writing has a positive effect on math anxiety, increases problem solving skills, and results in an improved use of cognitive and metacognitive processes (Taylor & McDonald, 2007). In this study conducted on group writing in a first year university mathematics course, students were given non-

routine type problems to solve such as finding the area of uneven shapes, constructing a soft drink can to hold 375 ml of liquid using the least amount of aluminum, and determining how long it would take for bacteria to multiply so that its weight is equal to the mass of the Earth. In each instance, the students were asked to write the aim of the problem, to specify the problem solving process, and to solve the problem. There was no conclusive evidence that the writing in groups produced correct solutions at a higher rate than a think-aloud process, but there was some evidence that the students' overall performance was better, especially in their mathematical communication skills and the solving of non-routine type problems. Students thought that communication, critical thinking, and writing skills learned in the group writing activities were transferable to other courses. Taylor and McDonald concluded, "The successful introduction of group writing into non-routine problem solving classes for first year university mathematics supports the premise that the formal introduction of writing skills into the mathematics curriculum is both possible and effective" (p. 653).

A study was conducted at Central Oregon Community College to determine the effects of writing and problem solving across disciplines. The institution provided 12 writing assignments for students in an Introduction to Contemporary Mathematics course and a Calculus I course. A sample writing assignment for the Contemporary Mathematics students consisted of constructing and labeling in detail a Venn diagram from the data provided. In addition, the development of the construction of the diagram was to be explained. An assignment completed by the Calculus I students was to explain a Gauss problem and to provide an example that was not shown in class. Agatucci, McCown, Sequeira, and Emerson (1994) found that the majority of the students thought writing in their mathematics course was helpful. Some testimonials from students in regard to writing were as follows: putting math symbols into words was difficult but worth the effort; writing helped in understanding problem-solving and enhanced memory. Also, the students recognized writing as a necessary life skill. Overall, the students gained critical and creative thinking skills and learned through authentic discovery.

In a study conducted by McFarland (1999), students major-

ing in secondary education who were taking their Content Area Reading and Writing in Secondary Education course were surveyed to obtain their input on how to integrate writing into various disciplines. The students' specific majors ranged from agriculture to math to theater. Students used their knowledge to design teaching methods to include writing in the curriculum. Mathematics students decided to include more essay exams to encourage higher order thinking, short research papers to aid in understanding math concepts, book reports to get students interested in mathematics, and journals to reinforce learning. A suggested daily journal entry by the students would be to write one new concept learned in math each day or to write something every day using a vocabulary word from the chapter that they were studying. The students who were surveyed believed that "writing assignments that involved higher order thinking, problem-solving, new knowledge, and student interest will make learning more meaningful and relevant" (McFarland, p. 15).

Because writing is a tool used to transform knowledge and aid critical thinking skills, integrating writing into a mathematics course can be an invaluable method for strengthening and building a deep understanding of math concepts. This strategy can produce three learning outcomes for mathematics students: understanding relationships of mathematical concepts and making connections, synthesis of various math components into a logical and systematic schema, and internalization of mathematical procedures (Blair, 2006).

A writing assignment provided by Agatucci, et al. (1994) that allowed students to understand mathematical relationships and make connections involved analyzing an article from a newspaper. The article provided statistics on banning assault weapons. The students were to determine if the statistics were used correctly and if the conclusions formed in the article were accurate. Long-term implications were to be explained based on their own conclusions. The purpose of this assignment was to challenge the students' thinking, to apply mathematics to a real-life situation, and to encourage students to write detailed explanations. The instructors expected the students to write clear and specific explanations of their analyses of the article so a person who is not knowledgeable

in math would be able to understand. Very few mathematics students understood that writing should be well-explained in order for anyone to understand their interpretations.

Huang and Normandia (2007) observed 51 lessons in a secondary mathematics course in which the teacher was an advocate of written and oral communication in the classroom. One of the writing assignments included in this study was to solve the standard form of a quadratic equation using the completing the square technique. They were to explain each of the steps in paragraph form and show the algebra separately. This assignment encouraged students to synthesize various math components in a logical and systematic schema and to internalize math procedures. The analysis of the students' writing by Huang and Normandia showed a relationship between the construction of knowledge and semantic relations. The semantic relations noted in the study of the quadratic equation assignment were as follows: taxonomic, means-end, condition-result, cause-effect, sequential, and evaluative. The more semantic relations expressed, the greater the conceptual knowledge.

Flesher (2003) noticed a similarity between learning mathematics and learning a foreign language. Mathematics has its own specific language and knowing math vocabulary is crucial to understanding mathematical concepts. Furthermore, there are many formulas in mathematics such as the Pythagorean Theorem, quadratic formula, etc., and Flesher believes mathematical formulas should be translated in writing for of the following reasons: writing can allow students to organize their thoughts, writing is a visual motor skill that allows people to see mistakes easier, writing allows students to review and revise activities or compositions, and "many people have dominant visual and motor memory, which means they learn written words more easily than words they just hear or read" (p. 38).

Writing enhances the understanding of mathematical concepts and aids in retaining information. There are many ways to incorporate writing into a mathematics curriculum and to use strategies that allow students to comprehend the relationships of mathematical concepts, synthesize various math elements into a logical schema, and internalize the sequence of math procedures.

Some writing activities that I have used in my classrooms are one-minute papers at the end of class, word puzzles, vocabulary assignments, and poetry (acrostic, cinquain, haiku, etc.). Two assignments that I have found to be successful are the vocabulary and acrostic poem assignments.

I implemented the vocabulary and acrostic poem assignments for the geometry unit for my developmental algebra classes. Using a Contructivist Learning Theory approach, students were given the assignment before I taught the geometry unit. Students randomly chose a geometry vocabulary word from a list of 25 words. The students were to use their textbook, Internet, and/or other sources to complete the assignment. The first writing assignment that I created was a vocabulary word assignment. The directions with a modeled example of the assignment were given to the students. The assignment with the directions and an example follows:

**Vocabulary Word Assignment**

1. Define the vocabulary word and give the properties of the word.
2. Write a proof or explain the properties.
3. Write a math problem and solve it using the vocabulary word.

Example: Square

1. Square – Rectangular polygon with four equal sides.
2. Proof (1st option):
   - In an isosceles right triangle, the angles measure 45°-45°-90°.
   - Place two identical isosceles right triangles (figure 1) opposite each other meeting at the hypotenuse to form a rectangular shape as shown in figure 2.

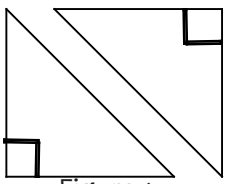

Figure 1

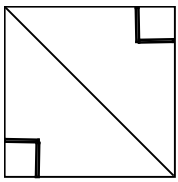

Figure 2

- The 45° angles meet to form 90° angles. Therefore, there are four right angles in the rectangular shape.
- Since the sides of an isosceles triangle are equal, all sides of the rectangular shape formed are equal.
- Thus, the shape is a square.

Properties (2nd option):

- The opposite sides are parallel.
- All angles are right (90°) angles.
- The diagonals are congruent.
- The diagonals bisect each other and form four isosceles right triangles.
- The diagonal bisect the angles.
- The diagonals are perpendicular bisectors of each other.
- Any pair of consecutive angles is supplementary.

3. Problem: The square polygon in figure 3 has equal sides of five inches. Find the area and perimeter of the square.

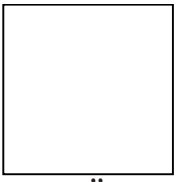

Figure 3

Area = 5 × 5
= 25 square inches

Perimeter = 5 + 5 + 5 + 5
= 20 inches

Since the area of a square is the number of square units within the figure, the area is found by multiplying the sides (5 × 5 = 25 square inches). The perimeter of a square is the distance around the figure. Therefore, the perimeter of the square is found by adding all of the sides (5 + 5 + 5 + 5 = 20 inches). The unit of measure for the perimeter is in inches because the perimeter is one-dimensional.

Another writing activity that I have found to enhance students' learning and understanding of math concepts is the acrostic poem. This type of poem has a title that is a word, motto, short phrase or short message. The title or message is written in a vertical column with the first word of each line in the poem beginning

with a letter from the title. Each line can be a word, phrase, or sentence with each line indicating something about the title. A student example follows:

Radius

**R**adius × pi × 2 = circumference
**A**lways found within a circle
**D**etermined by dividing diameter by two
**I**s always half of the diameter (d/2=r)
**U**sually associated with geometry
**S**egment from the center of the circle to a point on the circle

The following is a rubric for grading students' acrostic poems.

| | | | | |
|---|---|---|---|---|
| **Accurate description** | 6 points completely accurate | 5 points 1-2 errors in description | 4 points 3-4 errors in description | 0 points 5 or more errors in description |
| **Clarity of concept** | 6 points very clear | 5 points clear | 4 points somewhat clear | 0 points student did not show understanding of concept |
| **Grammar** | 5 points 0-1 errors | 4 points 2-3 errors | 3 points 4 errors | 0 points more than 4 errors |
| **Spelling** | 3 points 0-1 error | 2 points 2 errors | 1 point 3 errors | 0 points more than 3 errors |
| **Creativity** | 5 points very novel in presenting concept | 4 points novel in presenting concept | 3 points somewhat novel in presenting concept | 0 points no creativity |

In the acrostic poem assignment I was more concerned with students' understanding of math concepts. Therefore, more points were assigned for the accuracy of the description of the math concept and the clarity of the concept. Math is like a foreign language and the translation of the mathematical meaning must be clearly stated. The student's example provided a very clear and accurate description of the concept assigned, showed creativity, and had correct grammar and spelling. A perfect score (25 points)

was awarded to the student.

I conducted quantitative research with my Elementary Algebra students for each of the assignments described above to determine if students who had a writing assignment (the experimental group) would perform better on a geometry vocabulary quiz than the students who did not have a writing assignment (the control group). The experimental group was given the writing assignment which was due before the unit was taught. After completing the geometry unit, a vocabulary quiz containing 25 geometry words was given to these students. There was a matching section of the vocabulary words with the definitions and a matching section with the vocabulary words with pictures. Each section of the quiz was worth 25 points. The class average for the assignments and difference in scores of the experimental group and control group are shown in Table 1 and Table 2.

Table 1. Geometry Vocabulary Quiz Scores – Vocabulary Word Assignment

| | Experimental Group (EG) | Control Group (CG) | Difference in Scores EG – CG |
|---|---|---|---|
| Fall 2007 Average Scores | | | |
| Pictures | 22.65 | 20.63 | +2.02 |
| Definitions | 21.80 | 19.56 | +2.24 |
| Spring 2008 Average Scores | | | |
| Pictures | 20.69 | 20.00 | +0.69 |
| Definitions | 19.62 | 19.30 | +0.32 |

Table 2. Geometry Vocabulary Quiz Scores – Acrostic Poem

| | Experimental Group (EG) | Control Group (CG) | Difference in Scores EG – CG |
|---|---|---|---|
| Fall 2007 Average Scores | | | |
| Pictures | 21.81 | 19.91 | +1.90 |
| Definitions | 21.29 | 20.79 | +0.50 |
| Spring 2008 Average Scores | | | |
| Pictures | 21.18 | 20.23 | +0.95 |
| Definitions | 20.73 | 19.13 | +1.60 |

One could hypothesize that the experimental groups' average quiz scores would be one point higher than the control groups since the students in the experimental groups would be very knowledgeable about their assigned vocabulary word and would get their vocabulary word correct on the quiz. The data indicate that the experimental groups scored better than the control groups each semester, and the differences in the average scores range from 0.32 to 2.24. A possible discrepancy of the expected outcome is that many of the vocabulary words were familiar to many of the students before the unit was taught. But there does appear to be a positive correlation between writing and the understanding of mathematical concepts.

The vocabulary word and acrostic poem writing assignments can help students gain more in-depth understanding of mathematical concepts. It appears that integrating mathematics with writing can promote active learning and aid in critical thinking skills. In order for students to organize their thoughts and to create one of these activities in a coherent manner, they may be encouraged to read their math textbook and other material such as math websites on the Internet more intensively. It may also encourage more critical thinking since a deep understanding of various math concepts is necessary to complete the assignments.

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