WRITING IN THE MATHEMATICS CONTENT AREA

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WRITING IN THE MATHEMATICS CONTENT AREA

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Abstract

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Designed around research of literature and a classroom implemented writing activity, this paper focuses on how journal writing and other multimodal writing strategies improved the logical thinking skills of secondary level students and their overall ability to express their understanding of mathematical concepts covered in the classroom.

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CHAPTER 1
INTRODUCTION

Writing is a way for students to work themselves into a subject and make it their own (Zinsser,1988). If students learn to explain their thinking process as they solve a math problem (drawing, tables, graphs, examples as well as words), they can acquire a means of planning out their work logically. *In Principles and Standards for School Mathematics*, the National Council of Teachers of Mathematics states that "students who have the opportunities, encouragement, and support for writing, reading and listening in mathematics classes reap dual benefits: they communicate to learn mathematics, and they learn to communicate mathematically"(NCTM,2000, p.10). Many students memorize formulas and steps to complete an exam, without fully understanding where the formula came from or its main function. As students communicate mathematically, they will recognize the process with which they feel comfortable, as well as, those concepts with which they are struggling. If students cannot put into words what they are completing in the classroom, perhaps no real learning is taking place. Communicating mathematically will reinforce the students' interpretation of the material, as well as, help them to organize and maintain the information.

Statement of the Problem

This paper will address the topic of writing in the mathematics content area and answer the following three questions:

1. Does ability to write mathematically correlate to ability to learn and apply mathematical skills?
2. Does reflecting on what has been learned correlate with scores on an assessment of each unit covered?

3. Is mathematical dialogue an effective assessment tool?

Delimitations of Research

The investigations for this project and research paper are the experiences of trial and error with Algebra I (ninth graders) and Algebra II students (eleventh graders). Thirty –five classroom students, from a small rural Wisconsin school, have been assigned writing projects in the mathematic classrooms since November, 2009. The foundation for this study rest on research found in mathematics journals, "Using Writing To Teach Math" by Ganna Maymind, National Teachers of English (NCTE) Donald H Graves Writing Award Recipient (2005). Informing this study also were works of professional literature such as "Writing in Math Class" by Marilyn Burns (1994), Educative Assessment by Grant Wiggins (1998) and Reflective Teaching, by Kenneth Zeichme and Daniel Liston (1996). Research has been conducted through the Karrmann Library (University of Wisconsin-Platteville). Primary searches were conducted via internet through EBSCO Host with ERIC and Academic Search Premier. Key search topics include, "integrating writing strategy instruction with content area instruction," "writing and evaluating assessments in the content area," and "defining writing ability for classroom writing assessment in high schools."

Method of Approach

After discovering the vast body of research on writing-to-learn activities, and subsequently reading selected pieces, the implemented classroom writing intervention is based on a similar mathematical writing project model designed by Sarah E. Kasten from Ohio State University (2004):

1. Students took five to ten minutes of class time to explain, in their notebooks, their understanding of the daily concept covered. This included any questions or parts of the process that they still did not feel they understood. They were prompted by answering the following questions or statements:
    a. What did I learn today?
    b. I discovered that…
    c. I still don't understand…
2. One to two days later, students explained verbally (with a partner) their problem solving process for that specific content unit. Partners helped each other write down what they explained orally. Students were encouraged to include in their discussion their strengths and weaknesses of the unit, as well as mathematical terms discussed in class.
3. Students created and solved an example problem explaining (graphs, charts, diagrams, etc) their technique and thought process used. The goal was for students to think of what they learned in terms of concepts, not just memorizing steps and mechanically solving a problem.
4. Students applied the concept and thought process to a real-world situation. Students attempted to create a problem that they could solve using the concept covered.
5. Students created a two to four paragraph form essay explaining the mathematical method they used, described the process (steps involved), strengths and weaknesses of the unit, and a real-life application of the skill learned.

To evaluate and assess the written summaries, the following rubric was aligned with how results were categorized on the WKCE (Wisconsin Knowledge and Concepts Exam). This rubric showed the four levels of competencies: Advanced, Proficient, Basic and Minimal.

Advanced

Summaries/explanations demonstrate deep and thought provoking understanding of the concept covered. Explanation includes mathematical terms, inferences, and examples that defend your ideas. These examples are different than those presented in the classroom textbook. Summary includes comparisons of methods discussed. Summary includes realistic applications as to why/how the mathematical concept needs to be learned. All ideas and explanations are summarized in an organized method.

Proficient

Summaries/explanations demonstrate understanding of the concept covered. Explanation includes mathematical terms, inferences and an example that defends your ideas. Summary includes a realistic application as to why/how the mathematical concept needs to be learned. All ideas and explanations are summarized in an organized method.

Basic

Summaries/explanations demonstrate little understanding of the concept covered. Some attempt is made to include mathematical terms and an example to defend your ideas. Ideas and explanations are not summarized in an organized method.

Minimal

Summaries/explanations are incomplete and show no understanding of the concept covered. Summaries are identical to the description of the concept given in the textbook. No examples are shown and no real-life applications are given. Ideas and explanations are not summarized in an organized method.

CHAPTER 2
REVIEW OF THE LITERATURE

Writing in the mathematics content area

Secondary mathematic students will face many challenges academically if they are only exposed to a memorization of facts strategy for learning. Writing tasks need to be integrated throughout the curriculum in order to promote high level thinking skills (Langer and Applebee, 1990). As students prepare for postsecondary studies and the workforce, they are ultimately preparing their minds as life-long problem solvers. As David Eugene Smith, early twentieth century pioneer stated, caution needs to be used when having students memorize and recite a teacher-supplied formal analysis of a problem. Analytical skills need to be developed over time. Reflecting the spirit of American pragmatism, Smith urged that "unless there is such a decided superiority insane new form of solution as to warrant its introduction, the solutions of the business world should be adopted" (2006, p.560). Students need to be able to communicate their logical thought process in both a verbal and written form. These skills will be beneficial for any field of study. Writing and talking about mathematics helps students develop mathematical skills and concepts and observing their communication assists the teacher in planning instruction (NCTM, 1989).

It is the job of educators to motivate students and integrate teaching techniques that will encourage students to be life-long learners and problem solvers. According to the Journal of Adolescent and Adult Literacy, overwhelming support exists in the literature for using writing to learn in all content areas, from math to science to social studies. Writing to learn helps students take responsibility for their own learning and to reflect on their preferred learning styles. Writing to learn emphasizes better thinking (Johnson, 1990). Students who can recognize their questions and learn to seek help and clarification will be able to focus on further development of

ideas and skills. Frequent participation in write-to-learn activities also helps students improve their writing, even though that is not necessarily the main objective. Carefully chosen tasks require active involvement of students in connecting and integrating ideas as they write (Emig 1977; Fulwiler 1986; Gere 1985; Tchudi and Huerta, 1983). The goal of writing in the mathematics content area is for students to learn how to express their understanding and application of mathematics concepts.

As Wisconsin adopts Common Core Standards and regulates the following mathematical practices, writing-to-learn is essential (DPI, 2010).

Secondary Mathematical Practices:

1. Make sense of problems and persevere in solving them
2. Reason abstractly and qualitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning

Examples that the Department of Public Instruction gave as essential math goals include:

Math 8: Describe the effect of dilations, translations, rotations, and reflections on Two-dimensional figures using coordinates.

High School: Explain a proof of Pythagorean's Theorem and its converse, then apply to determine unknown side lengths of a right triangle.

These examples show that students need to be able to not only complete a math problem from first step to last, but also be able to explain how they reached their answer and apply those skills to a similar problem or field of study.

Although writing across the curriculum has been emphasized in the literature since the early 1980's, the National Assessment of Educational Progress found that student writing performances has shown little improvement over that period (Education Research Complete 1993). Langer and Applebee (1987) found that content area writing can be used to assist learning in three primary ways: 1) to gain relevant knowledge and experience in preparing new activities; 2) to review and consolidate what is known or has been learned; and 3) to reformulate and extend ideas and experiences.

Math Journals

Educators need to use different learning strategies to help students discover any gaps in their knowledge and explore relationships. As students answer motivating questions, they can reflect on the progress of their learning (Holt, Rinehart and Winston, 2004). "What did I learn or discover this week?" "What am I confused by?" "How can I apply the skills we used this week?" Students can use journal writing in math class to promote self-questioning, organizing of a step-by-step process and application of skills learned. Writing can be used to reflect, to clarify information and to discover one's own knowledge and opinions. Math journals can be used as an aid for learning math and can have two main functions (Wason-Ellam, 1987):

1. **Writing for informing** – which connects writers for an audience.

2. **Writing for learning** – which gets writers in touch with themselves and their skills.

Math journal writing will be a tool for developing further analytical reasoning; a tool to help develop language and communication skills as well as math concept learning. Math journals, used as a writing-to-learn activity, are designed to use writing as a process in which students generate and clarify understanding of mathematical concepts for themselves, rather than simply communicating with a teacher for evaluation (Prain, 2006; Wallace, Hand and Prain, 2004).

Alternative writing-to-learn strategies

Students' performance on essay exams and constructive response questions tends to improve greatly after they have become proficient at writing-to-learn (Sensenbaugh, 1999). Educators need to encourage students to become active and involved learners. Students need to draw on prior knowledge, make predictions, and apply and correct those predictions as they further their learning process. This can be enhanced with the use of multimodal learning strategies. Because some students have difficulty with the writing process, it is essential to create and incorporate alternative ways for them to express their understanding. Math students can use equations, graphs, charts, and diagrams to show their step by step thinking process. Julie Johnson and Melinda Holcombe write (Education Research, 1993) "creative writing belongs in every classroom because the creative impulse is central to the development, understanding, and application of knowledge." This creative writing can be incorporated into a math lesson on the steps to simplifying the quadratic formula. Students can write a letter to an absent student, or a parent, describing their thought process and include an example of how the quadratic formula was derived. Students will learn from describing the overall patterns used and justifying their statements (Applebee, 1981).

Mapping can also be used as an alternative strategy for writing to review a math unit (Johnson, Holcombe, 1993). Mapping includes incorporating different concepts covered and showing the relationships between all. This is a strong structure for setting up an essay explaining the steps needed, and students own self-assessment of the concepts with which they still need help. Another writing-to-learn strategy is having students write mathematical newsletters. Students write a weekly article explaining a concept covered in math class. Students would be encouraged to be creative in including other students' names and activities of interest as they write and solve math problems. Students would use a variety of ways to solve the problem. These strategies could include traditional problem solving, rhyming (or poems) to remember steps needed, or songs written to include the step by step process.

Life-long learners

The development of effective learning strategies is dependent upon exposure to effective models and environments, which facilitate practice and feedback (Weinstein, 1991). Writing to learn in the mathematics content area provides an environment for students to become more active learners. It is a strategy to help students learn there are many ways for them to help themselves solve a problem. As students prepare for college and to be life-long learners, they need to be wise processors of information, and they need to be able to communicate their solutions. Teaching students how to be more cognitively engaged by applying efficient learning strategies improves their academic performance overall (Weinstein, 1991). After completion of high school, students are expected to be able to perform at a higher level of thinking, as well as self-regulate their comprehension. Writing in the math content area helps students develop those self-regulating skills. Unfortunately, many students do not develop effective learning strategies unless they receive explicit instruction and the opportunity to apply these skills

(Rachal, Daigle, 2006). Writing to learn in the mathematics content area is one way to help prepare students become logical problem solvers and to prepare them for a college career.

CHAPTER 3
CONCLUSIONS AND RECOMMENDATIONS

The review of literature has made it clear that students' abilities to write mathematically correlate to their abilities to learn and apply their mathematical skills. Although evidence shows that multimodal strategies helps students across the curriculum, the study used in my classroom was based off of journal writing. Reflection on research considered, and the seven month writing strategy implemented, it was found that writing in the mathematics content area is a positive, beneficial activity for secondary students to review and explain the mathematical concepts they are learning. Writing to learn requires the teacher to change from being the sole source of information to being a facilitator who assists students in their learning and helps to strengthen students' awareness to the actual step by step process and logical thinking skills they are applying.

The classroom study showed over the seven month period of implementing a math journal essay strategy that these high school students' test scores increased approximately 12% on average (see appendix A). It is noted that A/B students had the least amount of improvement on their overall grade because they generally were very conscientious and studious. The biggest improvement came from students in the C/D range. The majority of these students needed the extra incentive to analyze their thought processes. They benefited the most from being required to show and state their step by step processes. Most students did not like to write the math summaries at the beginning of the implemented program. However, as time went on, several students realized the importance and the benefit of integrating their learning. Several students found this to be a great review technique for quizzes and tests; others indicated it was helping them to learn the material better and become more organized. As students

reflected, they often expressed that they were not comfortable with writing in math class, but felt that by the end of the school year they were able to ask better questions and help themselves pinpoint where their confusion was. During the last semester, improved communication in the classroom was documented. Most students were working more effectively in groups and were actually communicating using mathematical terms. However, writing to learn in the math classroom was the most challenging for students who were already apprehensive about their math skills. Students of lower self-esteem with mathematics felt even more nervous about having to add another component to the math class. They often copied from their text in order to complete the journaling activity. It is recommended that all students be given the opportunity to express how they feel about mathematics at the start of implementing math journals. Classroom teachers should take into account varying attitudes and how to address motivation of the students, and perhaps developing alternative assessment strategies or tasks. It is also recommended to grade the journaling and summaries after several examples have been completed together in the classroom. Students success rate increased as final summaries of the units, after personal reflection was completed, were written as an entire group. A rubric should be constructed and followed. Teacher driven prompts were helpful for personal reflection, such as:

1. What is the purpose of the unit? Why am I learning this?
2. What were the main topics/concepts covered in each section of this unit?
3. I can give a real-life application/example of each concept studied.
4. I can help myself to improve by…
5. My teacher can help me improve by…
6. What did I understand well as I worked with this unit?

7. I found that I seemed to struggle with…in this unit.
8. When I want to remember something, I find that I need to…
9. The section I feel most comfortable with is…
10. I am still confused by…

An additional challenge of incorporating writing-to-learn activities in the math classroom is that it is very time consuming for both the teacher to read and provide feedback, and the students to reflect, organize and then write a summary. This is in addition to the extensive course work at the secondary level that needs to be completed. However, despite the challenges, it is recommended that this strategy is worth spending the time invested on its implementation. As a result of this study, students communicated better with each other, and most students greatly appreciated the instructor taking the time to hone in on their strengths and weaknesses, while identifying where their comfort zone is. Research indicates that writing in the mathematics classroom is productive and this study shows improvement of test scores. Consequently, it would be beneficial to implement this into the K-12 curriculum. The sooner students feel comfortable expressing their mathematical abilities and steps to problem solving, the more they will feel comfortable expressing ideas in other, unfamiliar areas. Explaining and verifying the step by step process is a difficult and time consuming process. Students need to learn patience as their mathematical reasoning and self-confidence improves. To increase student success, teachers across the curriculum need to support the effort. Classrooms need to shift from traditional worksheet and memorization to one of communicating math. Through peer and teacher feedback, misconceptions and errors in understanding can be corrected. Not only can a different learning style be presented, more accurate assessment of students learning can take place. This strategy can open up the line of communication between peers and

instructors in order to help students learn math better. The goal of writing in the math content area is for students to learn how to express their understanding and application of mathematical concepts, and to improve their overall mathematical learning. Research shows students can reach this goal, and transfer their skills to the postsecondary level. The result can be life-long problem solvers and communicators.

REFERENCES

Andrews, S. (1997). Writing to learn in content area. *Journal of Adolescent & Adult Literacy, 41* (2), 141.

Burns, M. (1994). Across the curriculum: math in action. *Instructor, 103* (5). 28-40.

Donoghue, E. (2006). The education of mathematics teachers in the United States: David Eugene Smith, Early Twentieth-Century Pioneer. *Paedagogica Historica, 42,* (4 & 5), 559-573.

Hand, B. & Hohenshell, L. & Prain, V. (2004). Exploring students' responses to conceptual questions when engaged with planned writing experiences. *Journal of Research in Science Teaching, 44* (2), 186-210.

Johnson, J. & Holcombe, M. (1993). Writing to learn in a content area. *Eric Clearinghouse, 66,* (3), 155.

Kasten, S. (2004). A case for using reading and writing in a mathematics classroom. *Advancing Adolescent Literacy Instruction Together, 11,* 1-5.

Maymind, G. (2005). Math Journals: using writing to teach math. *Reading & Writing Mathematics,* 1-10.

McDermott, M. (2010). More than writing-to-learn. *The Science Teacher, 1*, 32-36.

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author

Rachal, C., & Daigle, S., Rachal, W. (2006). Learning problems reported by college students: Are they using learning strategies? *Journal of Instructional Psychology, 34* (4). 191-199.

Ross, J. & Faucette, D. (1994). Writing about math in English 101. *Viewpoints,* 10.

Sensenbaugh, Roger (1992). Reading and writing across the high school science and math curriculum. *Eric Clearinghouse on Reading.*

Suydam, M. & Kasten, M. (1985). Investigations in mathematics education. *SMEAC Information Reference Center, the Ohio State University, 18,* (3), 70.

Wadlington, E., & Hicks, K. (1994). Using process writing to teach problem solving to middle school and junior high students. *NCTM Curriculum and Evaluation Standards, 3,* 16.

Wason-Ellam, L. (1987). Writing as a tool for learning: math journals. *Eric,* 20.

Winston, Holt, Bennett, Jennie, Holt, Holt, Rinehart, Rinehart, Winston, and, & inc, inc. (2004). *Math: reading and writing in the content area.* Holt McDougal.

Wisconsin Department of Public Instruction (2010). *Wisconsin adopts Common Core State Standards,* retrieved from http://www.corestandards.org.

Zeichner, K., Liston, D. (1996). *Reflective Teaching.* Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

APPENDIX A

2009 - 2010

Algebra II-Assessments	Pts Earned/Pts Total	Class Average
Unit 1	48.8/62	
78.7%		
Unit 2	49.4/60	82.3%
Unit 3	52.1/60	86.8%
Unit 4	39.1/45	86.8%
Unit 5	48.7/55	88.5%
Unit 6	37.1/42	88.3%
Unit 7	75.4/90	83.7%
Unit 8	44.5/50	89.0%
Unit 9	52.1/60	86.8%
Unit 10	35.4/40	88.5%

Algebra I –Assessments	Pts Earned/Pts Total	Class Average
Unit 1	44.7/60	74.5%
Unit 2	49.1/60	81.8%
Unit 3	46.7/55	84.9%
Unit 4	68.9/80	86.1%
Unit 5	75.4/90	83.7%
Unit 6	38.9/50	77.8%
Unit 7	48.8/62	78.7%
Unit 8	48.3/60	80.5%
Unit 9	50.1/60	83.5%

2009-2010

Algebra II Unit 1 78.7% - Unit 10 88.5%

Algebra I Unit 1 74.5% - Unit 9 83.5%