Conceptual Writing and Its Impact on Performance and Attitude

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Preliminary Research Proposal

There is an abundance of recommendations and articles that extol the virtues of writing in the mathematics classroom. The National Council of Teachers of Mathematics encouraged mathematical communication in its 1989 *Standards for School Mathematics* and again in its update of the *Standards* (2000). The Mathematical Association of America (2004) underscored the need for developing communication skills in mathematics and was joined by a host of other countries that encouraged writing (Ntenza, 2006). Yet, with twenty years of advocacy by researchers and policy-makers, very few students have experience with mathematical writing when they come to college (Borasi & Rose, 1989; Ntenza, 2006, Pugalee, 2004).

In an earlier study, the authors of this preliminary research report modeled their writing assignments after a writing heuristic that used concept mapping, resources, and refinement (Keys, Hand, Prain, & Collins, 1999). Our experimental groups did eight graded writing assignments, each composed of two parts; an initial intuitive piece and a subsequent theme. The writing assignments were oriented toward concept(s) that were currently being taught in the course. The intuitive piece was designed to be a structured concept mapping that would allow students to reflect on the vocabulary, relate the concept to prior knowledge, consult resources, provide examples and counter-examples, and identify areas of confusion. Then the students wrote a theme that was designed to answer specific questions related to the concept explored in the intuitive piece. Each theme assignment was also presented to the control group as an in-class exploration with the discussion ultimately leading to a solution. Thus, all students in the study discussed the theme's concepts; the students in the control group did homework problems related to the concepts, while the students in the experimental group did fewer problems but wrote about the concepts.

We found the writing groups improved more than their control group counterparts numerically on a post test; but the difference was not significant overall except in the case of the lower level mathematics class. Furthermore, the authors found that within the groups who wrote about mathematical concepts: 1) females had more negative attitudes about communicating mathematically than males, and 2) students who were the most diligent in their writing about concepts had significantly more negative attitudes about their ability to do mathematics which seemed to correspond with the adage, "The more I learn, the less I know,"

While the concepts were related to those taught in the courses, the construct of the questions on the pre- and post-tests were wholly different from the in-class conceptual writing assignments. We concluded:

> In providing structure for the assignments and aiding in the planning stage (Flower & Hayes, 1980) we hoped to encourage students to produce well-thought out, carefully revised pieces but it may be that they would be more invested if the assignment was of an argumentative nature where students are asked to defend divergent views. Motivation in argumentative writing has been shown to be a key factor in cognitive gains. (Voss, Wiley, & Sandak, 1999) It may be possible that brief conceptual pieces that allow for arguing a position would be more effective. (Authors, submitted for publication)

The authors believe that more focused writing is key to conceptual understanding and are now in the process of piloting particular writing assignment questions. For example, one writing assignment question will be motivational in its challenge to argue a position on why students tend to miss particular concepts within a problem. Another writing assignment question will be direct in asking students to explain what concepts are important in the context of a given problem. When we have determined the type of question that elicits the most effective response, we will replicate our study on a larger scale using focused conceptual writing. Our research questions will be the same as our previous study.

- Do students in a course that requires writing do better than students in the same course that requires no writing?
- Do students who write about concepts regularly improve more on a visual skills assessment than their counterparts who did not write about concepts on a regular basis?
- If students write regularly about concepts in a mathematics class, does their attitude toward mathematics change?
- Do students believe the writing assignments help them understand the material better?

The Literature

Although much has been written about the benefits of writing in the classroom, the results are mixed from the relatively few studies that compare the learning of students who write with students who do not write. One such study was done by Pugalee in which one group of high school algebra students provided written descriptions of problem solving processes and the other provided verbal descriptions. He concluded, "Students who wrote descriptions of their thinking were significantly more successful in the problem solving tasks ($p<.05$) than students who verbalized their thinking" (Pugalee, 2004, p. 27). Two comparative studies from the early 1990's on college algebra classes found that students who wrote did better on algebra skills exams (Guckin, 1992; Youngberg, 1990). Porter and Masingila (2000) collected data from two sections of calculus. One section of students wrote about their activities and the other did not. Categorizing errors from in-class and final examinations to assess procedural and conceptual understanding, they found no significant difference between the writing and the non-writing groups. Their conclusion was that the nature of the activities may be more important than the writing itself. There is also very little research about attitudes toward writing in mathematics courses and the impact writing has on attitude toward mathematics and most of the evidence is anecdotal.

Theoretical perspective

A great deal of research exists on the cognitive processes involved in the act of writing. A classical model was developed by Flower and Hayes (1981) and confirmed by many later studies.(Alamargot and Chanquoy, 2001) Successful writers are seen as going through recursive stages of planning, then translating , and finally revising and reviewing. The planning stage entails generating ideas using memory and resources, organizing the ideas and setting goals. Our experimental treatment, having students write about mathematical concepts that had been discussed, aided students in the planning stage. The assignments were selected as a possible tool for bridging the gap between Vygotski's 'potential concepts,' so named because they indicate an ability to solve problems that stem from a familiar context or routine algorithm and the distinctly higher, more flexible, conceptual ability to solve complex, non-routine problems independently

(Sierpinska, 1992). The possibility that students could demonstrate conceptual understanding by being able to apply what was learned to a visual skills assessment that was not directly related to the course should not be construed as a permanent and all-encompassing ability to solve problems independently. However, if it could be demonstrated that students who write about mathematics show evidence of significant gains over their non-writing counterparts on such an instrument, then the persuasiveness of using writing as an instructional device would be more compelling.

Research methodology

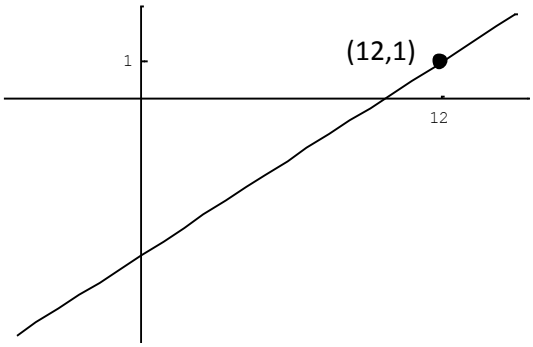
Our previous study was small with participation by two faculty members and their students in two Finite Mathematics classes and two Applied Calculus classes. We plan to conduct the next study with a larger group involving college-level mathematics courses from other universities in the area. We will have an experimental and control group and will change the treatment to more focused conceptual writing. There will be a pre-test and a post-test using a visual skills assessment of 10 or more items that concentrate on four areas; Cartesian Connection, Slope, Function Notation, and Monotonicity. This assessment was designed to measure the comfort level of students entering calculus with the Cartesian Connection and Basic Principles of Graphing (Van Dyke & White, 2004).

As an example, see Figure 1 below. We put the point very close to the equation and used coordinates that do not call for burdensome arithmetic. If the test takers understand the Cartesian Connection, they should be able to easily provide the correct answer to the question.

Figure 1

Consider the following equation along with its graph.

3x-7y=29



Choose one of the following statements.

a) An obvious solution in integers to the equation 3x-7y=29 is_____.

b) I see no obvious solution in integers to the equation 3x-7y=29.

Our conjecture is that conceptual writing is not routinely practiced at the grade-levels where it can quite possibly have the most impact; middle school through high school. If the indicators for using conceptual writing are positive, there will be more impetus for encouraging this pedagogy early and regularly. This, in turn, may help with the phenomenon that we observed in our students' expressed belief that writing in math was not appropriate. Both students and teachers stand to gain if writing becomes a regular part of the mathematics curriculum.

References

Alamargot, D., & Chanquoy, L. (2001). *Through the Models of Writing*. The Netherlands: Kluwer Academic Publishers.

Borasi, R., & Rose, B. J. (1989). Journal Writing and Mathematics Instruction. *Educational Studies in Mathematics , 20*, 347-365.

Flower, L., & Hayes, J. R. (1981) A Cognitive Process Theory of Writing. *College Composition and Communication* 32(4), 365-387Guckin, A. (1992). The Role of Mathematics Informal Focussed Writing in College Mathematics Instruction (Doctoral Dissertation, University of Minnesota, 1992). *Dissertation Abstracts International , 53* (5), 1435A.

Keys, C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the Science Writing Heuristic as a Tool for Learning from Laboratory Investigations in Secondary Science. *Journal of Research in Science Teaching , 36* (10), 1065-1084.

MAA. (2004). *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004.* Mathematical Association of America, Committee on the Undergraduate Program in Mathematics of The mathematical Association of America. Washington, D. C.: Mathematical Association of America.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics.* Reston, Virginia: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Ntenza, S. P. (2006). Investigating Forms of Children's Writing in Grade 7 Mathematics Classrooms. *Educational Studies in Mathematics , 61* (3), 321-345.

Porter, M., & Masingila, J. O. (2000). Examining the Effects of Writing on Conceptual and Procedural Knowledge in Calculus. *Educational Studies in Mathematics , 42*, 165-177.

Pugalee, D. K. (2004). A Comparison of Verbal and Written Descriptions of Students' Problem Solving Processes. *Educational Studies in Mathematics* , 27-47.

Sierpinska, A. (1992). The Development of Concepts According to Vygotski. (J. Schmittau, Ed.) *Focus on Learning Problems in Mathematics , 15* (2&3), 87-107.

Van Dyke, F., & White, A. (2004). Examining Students' Reluctance to Use Graphs. *Mathematics Teacher , 98*, 110-117.

Voss, J. F., Wiley, J., & Sandak, R. (1999). Reasoning in the Construction of Argumentative Texts. In J. Andriessen, & P. Coirier, (Eds.), *Foundations of Argumentative Text Processing.* (pp. 29 – 41). The Netherlands: Amsterdam University Press.

Youngberg, S. A. (1990). The Effect of Writing Assignments on Student Achievement in a College Level Elementary Algebra Class (Doctoral Dissertation, University of Iowa, 1989). *Dissertation Abstracts International , 50* (9), 2819A.