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ABSTRACT

A study was undertaken at Central Arizona College to determine the effect of writing activities on student performance in College Algebra. An experimental group of eight students was established and given lists of math-related vocabulary words and problems which required written explanations. Quizzes were constructed requiring the group to respond in writing, while eight students in a control group took standard quizzes. A standard final college algebra examination served as the post-test for both groups, while the experimental group also completed a survey on their perceptions of the writing activities. The mean test score on the final examination was 84 for the experimental group and 74.3 for the control group. Conclusions drawn from the scores and from responses to the survey included the following: (1) the small sample size did not make the difference in mean test scores significant; (2) students who excel in mathematics may not benefit from writing assignments but lesser prepared students may benefit a great deal; (3) experimental group responses indicated that students were generally positive about writing activities, with five of the students agreeing that the assignments helped them to understand algebra, two expressing no opinion, and two disagreeing; and (4) in general, students did not understand that the writing assignments were meant to help them learn algorithms rather than show the teacher that they could communicate math concepts in writing. (Appendixes include test scores, the survey instrument, student and teacher comments, and writing samples.) (KP)

Final Report for the Title III Literacy Across the Curriculum Team

College Algebra and Writing: A Pilot Project Spring Semester 1994

by Jeff Ross and Dixon Faucette

Location: Central Arizona College–Superstition Mountain Campus

Instructor: Dixon Faucette

Courses: Two sections of Math 104 College Algebra

Section JH MWF 8:30-9:50

Section JB MWTH 5:15-6:45

May 18, 1994

Purpose

1. To determine if writing activities improve student performance in Math 104 College Algebra.
2. To assess qualitatively student perspectives of writing activities in mathematics courses

Selection of Experimental and Control Groups

While not truly experimental, this pilot study sought to determine the effects of a certain treatment on one group of college algebra students. The treatment involved writing out explanations for algorithms.

One section of Math 104 served as the experimental group (E); one section served as the control group (C). The two sections represented a census of the Math 104 courses taught at CAC-SMC Spring semester 1994. Each class was given its first exam during the third week of class. (Both sections were taught by Mr. Faucette.) The first test was a one hour exam based on standardized algebra test questions with no writing involved. The section which had the lowest group mean score on the first exam, Section J, served as the E group.

Instructional Methods

Traditionally, students work out algorithmic exercises to develop competency in mathematics. Mr. Faucette implemented instructional changes in the E section which emphasized writing activities. Students in the C group were given traditional college algebra instruction.

I. First, Mr. Faucette gave E group students lists of vocabulary words (math-related) to study and to define. Next, Mr. Faucette assigned problems, based on material covered in the course, which required written explanations. (A total of 20 discussion questions were given to the E group students during the courses of the semester). For example, students were asked to explain the Gaussian Elimination procedure. (See samples in **Appendix E.**)

II. Next, Mr. Faucette constructed examinations and quizzes which required the E group to respond to questions in written format. These questions asked the students to either explain and/or define an algebraic concept or operation. C group students took standard quizzes and examinations.

III. Finally, a standard final college algebra examination (without written explanation problems) served as the study's post-test for both groups.

Evaluation

I. Two "standard" methods of evaluation were used in this pilot study:

A. The E and C groups' mean scores from the final exam (the post test) were compared. using the Student's T test for independent samples. The scores, means, and T test results are described in **Appendix A**. Discussion of the results appears in the Conclusions section.

B. Students in the experimental group were asked to complete a survey. The results can be seen in **Appendix B**.

II. Qualitative forms of evaluation were also used:

A. Jeff Ross interviewed Dixon Faucette thrice during the course of the semester. Mr. Faucette was interviewed (1) during the development of the design; (2) at midterm, and; 3) at the conclusion of the project. Highlights of the interviews can be seen in **Appendix D**.

B. E group students were interviewed at the conclusion of the semester. Highlights can be seen in **Appendix C**

Conclusions:

1.The T test showed that the E group did not perform significantly better than the C group on the post test. Small sample sizes in this study may have contributed to the lack of statistical significance. However, the E group's mean on the post test (84) is "better" than the C group's mean (74.3). We believe factors other than writing activities may have been responsible for the higher E group mean, including their maturity, ability, and motivation.

2. Math faculty who use writing in their classroom need to help students make the distinction between **writing to communicate** and **writing to learn** (the public and private voices).

3. Students who excel in mathematics may not benefit from writing assignments; lesser prepared students may benefit a great deal.

4. Math instructors must determine how the written assignments are to be crafted: Should the writers heavily paraphrase responses from math text books, or should students be encouraged to explain the concepts using their own words and ideas?

5. In class writing assignments may be more valuable than out of class assignments.

6. Contextualized assignments are the most effective.

7. Both students and faculty in a writing-enhanced math course may be concerned about extra workload and time constraint issues.

8. The E group interviews were generally positive about writing activities in algebra. Some significant messages emerged during the interviews:

a. The vocabulary word assignments were the most helpful exercises.

b. It was difficult to find the words to express really abstract mathematical concepts

c. Time was an issue with many students. They were concerned with the extra time required to write out explanations.

d. Students have different perceptions about the purpose of the writing assignments. There was some confusion about the audience for the written assignments. As a group, the students did not understand that these writing assignments were meant to help them learn algorithms, not to show Mr. Faucette they could communicate math concepts in writing.

e. Students also believed that the writing assignments would have been more valuable if they were used to explain concepts to other students (writing as tutoring, perhaps). Mr. Faucette agreed that the writing would be more useful if the students were able to view it as a teaching/learning tool of their own.

Attachments:

Appendix A: Statistical study: T test results
Appendix B: Copy of survey and responses
Appendix C: Student interview responses
Appendix D: Faucette's interview responses
Appendix E: Sample written responses to algebra problems

Appendix A

E group Post test scores **N=8**	C Group post test scores **N=8**
100	82
92	56
86	94
72	64
60	75
96	76
80	62
86	86
Mean 84	Mean 74.3

T was **not** found to be significant

1.64 < 2.947 @.05 level

14 df (16-2)

We accept the null hypothesis that the two groups came from the same population. The E group did not perform significantly better than the C group.

Appendix B

MATH WRITING SURVEY **Math 104** **Spring 1994**

Please respond the following statements by circling the number that best describes your beliefs.
Numbers in ( ) below the scale line show number of responses **N = 9** **Differential** (- +)

1. I was surprised that we were asked to do writing assignments in this course.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
		(1)	**(6)**	**(2)**	**(+8)**

2. Mr. Faucette satisfactorily explained the purpose for the writing assignments.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
			(7)	**(2)**	**(+9)**

3. I felt comfortable writing about algorithms.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
(1)	**(2)**	**(3)**	**(3)**		**(+0)**

4. I was concerned about my grammar and spelling when I did the writing assignments.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
(4)	**(1)**	**(2)**	**(2)**		**(-3)**

5. The writing assignments helped me to understand algebra.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
	(2)	**(2)**	**(5)**		**(+3)**

6. It is easier to work out math problems if I am also able to write about them

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
	(3)	**(3)**	**(3)**		**(+0)**

7. I would advise students to use writing as a means to better understand algebra.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
	(3)	**(2)**	**(4)**		**(+1)**

8. I would like to see more writing assignments in every math course from Math 090 through College Algebra.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
	(3)	**(2)**	**(3)**	**(1)**	**(+1)**

9. The writing assignments should be counted as part of my grade.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
(2)	**(1)**	**(2)**	**(4)**		**(+1)**

10. Writing about algorithms is a waste of time.

1	2	3	4	5	
Strongly Disagree	Disagree	No Opinion	Agree	Strongly agree	
	(5)	**(2)**	**(2)**		**(-3)**

** Please place additional comments on the back of this form.**

Student Written Comments From Surveys

The additional assignments made it difficult to keep up with the book. The problems from the book easily consumed the majority of my time each week. When you combine the projects, writing assignments, book work, tests, quizzes, etc., it is difficult to develop a schedule for the class.

I think that my time could have been better used practicing [problems] than writing.

Appendix C

Pieces from the E group interviews completed during the 16th week of spring semester 1994

Three themes emerged during informal discussions with the E group students in MATH 104. The themes were *Writing to Learn in College Algebra, Audience for the Papers*, and *Time Allocated for the Assignments*.
In each theme group, each block represents a different student's perspective.

Theme 1: Writing to Learn in College Algebra.

I actually think it helped. . . . It's a way of, it seems to help get the idea of what you're are doing into your head rather than doing 50 problems of the same kind of thing. You have to think about the actual way it is done; you pick it up a little quicker.

Well, I think you retain more after you write it, I think you figure out more about how it works.

This was a different kind of class; in intermediate we did more book homework. It [writing] gives you a better understanding of the rules.

On the writing part-- when you have to write about an algorithm, it forces you to think about it and, uh, coerces you to actually learn more about it. Some things are hard for me to understand-- writing about it helps more in some areas than others. I think there is a lot of promise in this idea. One thing I noticed is that I found it more useful to be writing about things that aren't really complex; it seems to make more sense to be writing about algorithms that are basic rather than really complex ideas. Sometimes you work out the really complex ideas with sight and feeling rather than being able to write about them. I think doing the vocabulary words was probably the best part of it. It just made more sense to me to write about something like that rather than complex algorithms. Maybe we have the complex symbols and stuff because there are no words to explain them.

Writing in any course is good because it sharpens writing skills. I don't think writing about math helped me. But I think it would help students who have trouble with the concepts to organize their thoughts. But I don't have any such trouble. Memorization is my trouble. I'd prefer spend time doing the problems. Doing the problems to reinforce procedures is my major problem, the memorization. A lot of the time spent on [vocabulary] was wasted. I just internalized it. All that stuff in the symbols is difficult. Trying to translate it into English is difficult. I would rather internalize the concepts and work out the problems. I don't know, about writing in basic math; [writing] didn't do me much good. But other students appreciated it. Back in the 60's when I was in high school, we didn't have any vocabulary or new math, uh, we weren't taught all the vocabulary, we learned procedures and numbers, and I remembered more of my high school algebra than the intermediate course that I just had! Of course, the pace wasn't as bad-- but we just did problems over and over again and it became automatic after awhile. The pace is so quick now. I remember some procedures, but I have forgotten procedures we studied 2-3 weeks ago.

The definition sheet was good. In the prior classes we were told we didn't need to know the terms. But if you're talking to someone about a root and you don't know what a root is, well, knowing this helps a lot. Everyone I talked to thinks this was a good exercise, but we need the time to work out the problems. You don't really get the time you feel you need. I spend 2-3 hours a day on this stuff and I don't get to concentrate because I have these written algorithm assignments to do. Some of this helped but . . . .

Theme 2: Audience for the papers

One thing that might help-- well, it could have been clearer about what was wanted. Was it for ourselves or for the teacher? Like a sixth grade assignment, making a peanut butter sandwich. If we wrote it like that, like a program, every contingency, we might have gotten a little more out of it; it might have been more clear.

I was meeting the requirements of the assignment, recognizing my audience was Professor Faucette, I mean, it was being graded by him so I had to consider that, too.

I was writing for Dixon Faucette. Sure. Well, if you're writing to communicate, you need someone to write to, someone who knows about it, and it might as well be your teacher.

I have a suggestion. . . . If you walk someone through a problem, it will be helpful. I think It might be better if students walked other students through problems. It helps you, talking and writing, if you can help someone else learn. This might work better than the formal writing about algorithms. In the book they give you three steps to do for an algorithm; in the writing assignments you could use the same wording as the book but it really didn't teach you anything. I think a lot of people learn better if you explain something to some one else. We were handed other peoples' assignments after the first algorithm but we didn't spend much time on this. This might be more useful in 100 or 101. And some writing would be OK if it were more informal and written to students. I remember in elementary school we had to go to the board and explain things to the class. That was really good.

Theme 3: Time Allocated for the Writing Assignments

The time didn't really bother me-- it is study time presented in a different manner. . . . There's a lot of work in there anyway, and it's hard to tell just what might be extra time and what isn't. This stuff is hard.

I don't think we spent that much time doing writing-- there were only two or three times we really had any writing assignments. I know it did help some of the people in there. If you already know the concepts, I think it is a waste of time.

The farther you go into math, the more new concepts come up. I'm not good at math, it's very difficult. I feel like all my time needs to be used, uh, practicing equations. This seems to be the right way. I can see the value in it, but there is the time factor.

Appendix D

Excerpts from Interviews with Dixon Faucette.

Faucette 1: Development of the Project: January

I've been listening to these presentations and I've read some of the articles. This writing has to be a good thing for these people. We probably ought to get them to write out explanations to problems, you know, instead of just imitating the processes, and then get them to read them to each other. You know, one thing I could do that would be really easy would be to get them to just write me notes on little pieces of paper about what they learned, or what they ought to learn or like to learn. These people have a lot of trouble with algebra; I'm really in favor of anything that would help. I'd really like to get them more involved in learning. I need to try some things that really help them to learn what is going on. Well, I want to start out by giving them vocabulary words and then having them write out algorithms. I'm not sure about how to fit all of this extra work into a college algebra course.

Faucette 2: Midterm: March

Grading math essays is difficult. What one student writes is sufficient for him as compared to another student. For example, XXX made a statement that is clear for him but wouldn't be so for another student. We were writing out the algorithm for solving inequalities. Some of the students' explanations were very brief, very much to the point but little detail. Others go into very detailed explanation. I asked them to write the summary up so that it would be useful to themselves, that they could use to solve the problems, and this really reflects the different back ground that the students have. This is going to be a valuable experience. I want them to share their algorithms with each other and give each other reactions. It'll be interesting to see how they react to each others' response. Reactions have been mixed. The students have come to see there is more value in this. I think we have seen some improvements.

Faucette 3: Final exam week: May

I believe the E group would have improved more than the C group without the writing assignments. They were more mature and in general had better math aptitudes. The better math students did not benefit as much as the students with math anxiety due to backgrounds and deficiencies. Collaborative learning and writing out the definitions seemed to be most useful. Well, I probably should have had them do some plus/delta at the end of each period or the beginning of an hour. That's a nice way to get them to write. I don't know, probably shorter responses, the vocabulary was good and probably should have continued to stress it. I think that writing to explain it to someone else--the audience needs to be better defined. This made it difficult for me to judge. I had to make decisions about their math backgrounds because they were writing to me. If I could check their explanations to other students, I'd get a better handle on how well they learned the material. It takes a lot of time.

Taking the assignment home and writing out of the book probably isn't as useful as writing a quick response in class. You might get some insight about their problems in class because you'd get unrehearsed feedback. Um, you need to mix it up, different students respond to different kinds of writing assignments. When I first started, I was asking them to discover er domain and range, but on the other hand, I gave them assignments in which their were applied definitions to use in the problems. The solution followed from knowing the definition. I put some thought, I had exercises that were well coordinated with the writing assignments (definition), I put it into context, and it seemed to really whet there appetites to learn the definitions and the concepts. It motivated them, instead of asking why are we doing this, they started seeing value in this.

Appendix E

Samples of Student Writing

A polynomial function can contain real zeros that are irrational numbers. Therefore, it would not have rational zeros.

A) A polynomial function can have no rational zeros but still have real zeros. All the zeros to the polynomial function would have to be irrational numbers. For example, x^2-2x-2 has the zeros of $1 \pm \sqrt{3}$. These zeros are real numbers, although they are not rational numbers

B) Yes a polynomial function which has three real zeros only one of which is rational, the other two must be irrational.

C) ~~Because the leading term in this polynomial function is third degree,~~ it must cross the x-axis at least once, therefore there must be at least one zero, although it does not have to be rational.

DISCUSSION PROBLEM p371

The zeros of a function are the values for which the function is zero. For example, $f(x) = x^2 - 25$ has two zeros: 5 and -5. Sometimes, we use information about the graph of a function to help find its zeros. In other cases, we information about the zeros of a function to help sketch its graph. There are several equivalent statements about real zeros if f is a polynomial function and a is a real number.

1. $x = a$ ia a zero of the function f.
2. $x = a$ is a solution of the polynomial equation $f(x) = 0$.
3. $(x - a)$ is a factor of the polynomial $f(x)$.
4. $(a,0)$ is an x-intercept of the graph of f.

From this, we see that finding zeros is related to factoring and finding x - intercepts. On the other hand, rational zeros are the rational values for which the function is zero. There is a test mentioned in the book called the rational zero test that helps identify the rational zeros of a function.

RATIONAL ZERO TEST

If the polynomial $f(x) = a_n x^n + a_{n-1}x^{n-1} + \ldots a_2x^2 + a_1x + a_0$ has integer coefficients, then every rational zero of f has the form: Rational Zero = p/q where p and q have no common factors other than 1, and

p = a factor of the constant term a_0

q = a factor of the leading coefficient a_n.

(a)

Is it possible for a polynomial to have no rational zeros but to have real zeros? If so, give an example. A polynomial function can have real zeros but no rational zeros: for example, $f(x) = x^2 - 5$ the real zeros of this function would be $\pm\sqrt{5}$, however, they are not rational numbers, so there are no rational zeros.

GAUSSIAN ELIMINATION

A system of equations may be simply solved if it appears in row-echelon form. In this form, each equation has a leading coefficient of 1, each contains one less variable than the preceding equation, and the set is arranged in a stair-step pattern. The following system of equations is in row-echelon form:

$$\begin{aligned} x - 2y + 3z &= 9 \\ y + 3z &= 5 \\ z &= 2 \end{aligned}$$

Gaussian elimination can be used to change a system of equations not in row-echelon form to an equivalent system which is in row-echelon form. This process involves a series of steps in which any of the following operations may be used:

1. Interchange two equations.
2. Multiply one of the equations by a non-zero number.
3. Add a multiple of an equation to another equation.

The first step is to ensure that the first equation has a leading coefficient of 1. If this is not already the case, the operations are used to create a new, equivalent, equation whose leading coefficient is 1. Next, the operations are used (if necessary) on the second equation to create a new equivalent equation whose leading coefficient is the additive