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ABSTRACT

This study ascertained the relative effectiveness of writing assignments in mathematics compared to traditional assignments on the performance of students (N=83) in an elementary, college algebra course. Students were placed into experimental and control groups based on the nature of assignments given. Control subjects were given 15 assignments covering mathematics problems while experimental subjects were given 15 assignments requiring written responses to conceptual questions. To control for teacher effects, assignments were marked by an independent grader, teachers were not informed as to which group individual students were assigned, and teachers were instructed not to answer questions regarding the writing portion of the assignments until after all reword assignments were returned. Of the students completing a pre-established proportion of assignments, no significant differences were found between groups on either pre- or post-performance measures. Significant moderate correlations between the number of assignments completed and performance were found for both groups. It was concluded that writing assignments employed without teacher engagement were not more effective than traditional mathematics assignments. (Author/JN)

The Relative Effectiveness of Writing Assignments in an Elementary Algebra Course for College Students

Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Canada, April 12, 1983.

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ABSTRACT

The purpose of this study was to ascertain the relative effectiveness of writing assignments in mathematics as compared to traditional assignments on the performance of students in a elementary algebra course for college students. Eighty-three students placed into four sections of an elementary algebra course were randomly assigned to experimental and control groups. Experimental and control subjects were distinguished only by the nature of the assignments given during the term: control subjects were given 15 assignments covering math problems only, while experimental subjects were given 15 assignments requiring written responses to conceptual questions. In order to control for teacher effects, assignments were marked by an independent grader, teachers were not informed as to which group individual students were assigned and teachers were instructed not to answer questions regarding the writing portion of the assignments until after all reworked assignments were returned. Of the students completing a pre-established proportion of assignments, no significant differences were found between groups on either pre- or post-performance measures. Significant moderate correlations between the number of assignments completed and performance were found for both groups. It was concluded that writing assignments employed without teacher engagement were no more effective than traditional mathematics assignments.

In addition to content deficiencies in mathematics, most students placed in developmental mathematics courses arrive with a legacy of other associated problems as well: poor study habits, negative attitudes toward mathematics, low academic self-concept of ability. As a result of these problems, and the staff and time constraints in developmental mathematics courses (and certainly the nature of the topic as well), the material is poorly learned or, at the very least, poorly understood. Students resort to memorizing material: attacking problems in a rote manner and responding compulsively.

Rather than attempting to understand a problem or the concept illustrated by the problem, and then solve the problem through a rational process, the student usually responds to certain problem cues and goes through the memorized steps needed to arrive at a solution. This approach may get the student to the solution of the problem, but material learned in this manner is less likely to be transferred to other concepts or retained for any length of time. In addition, learning the material in this manner makes the learning of more complex material more difficult.

In class, the teacher may painstakingly explain each concept and its relationship to the problems being solved; justifying each step of a problem and describing the interrelationships between concepts. The student may very well understand the teacher's explanation at that time. Then the teacher spends time working on problems in class and assigns problems for student to do at home.

Eventually the problems, rather than the concepts which the problems illustrate, take precedence: the relationship between problem and concept is severed: the "hows" are emphasized and the "whys" are forgotten. The text usually reinforces this emphasis by grouping together similar problems--similar in the sense that they are solved in the same way. Usually the student will work on a group of problems referring back to worked-out examples rather than explanations. The student learns a few discrete skills in this manner.

What frequently happens is that the student's memory becomes overburdened. Problems requiring a sequence of steps become too difficult for the student to complete without making an error along the way. Interference occurs: problems which are conceptually different are treated as though they were the same because a few of the problem attributes may be similar. The student may view this as a careless error when in fact the error is usually due to a misunderstood or unlearned concept.

Part of the problem, of course, is the time factor and the emphasis placed on skills in the courses. The student quickly perceives that success in the course is measured by skill in algebraic manipulation: concepts become excess baggage--explanations are the teacher's obligation but the student is not obliged to understand these explanations. The students may learn the skill through practice, but they do not actively think about the problem, the concepts it illustrates, or why they are doing what they are doing to get to a problem solution.

Recent research into the composing process indicates that writing can be an effective instrument for getting students to spend time thinking productively about the problems they are solving and concepts they illustrate. Writing researchers and educators such as Emig (1977), Vygotsky (1962), Odell (1980) and Irmscher (1979) have emphasized an important link between writing and learning. Writing, they point out, is a form thinking takes. As Emig notes, writing is a major means of connecting experiences--past, present and future. And as Vygotsky adds, "writing helps tie down ideas to make connections between old and new concepts " (Vygotsky, 1962, p. 92.). The current Writing Across the Curriculum movement is based on this theoretical framework--writing helps students better learn any subject matter because it allows them to explore their thoughts, record them, and make connections between them. Writing helps students to define, elaborate and organize--in short to think (Strong, 1983, p. 35).

Since the Writing Across the Curriculum movement began several years ago, teachers in a variety of disciplines from elementary school through college have reported successfully using writing to help their students learn course material. Wotring (1980) found that the performance of high school chemistry students who kept journals or "think books" improved dramatically and they developed more self-confidence. She found that as her subjects wrote, they were able to see what they knew about the topic and what questions they had.

In the field of mathematics there have been several recent articles on Writing in the Mathematics Class. King (1982) shows that writing in the math class can fall into two of the modes of writing defined by Britton (1975). Math writing assignments can be expressive (writing to clarify one's thoughts, writing for the self) or transactional (writing to inform, explain or persuade writing for others.) Expressive assignments in math can include journal writing, free writing, letter writing or daydreaming. Transactional writing in the math class can take the form of summaries, questions, explanations, definitions, reports, or word problems.

Johnson (1983) also sees writing as being a valuable tool for learning. Like King, Johnson recommends a number of writing assignments for the math class. He suggests rewriting problems students do not understand, writing algorithms, writing essay questions, and writing historical mathematics papers.

Several teachers of mathematics have reported actually using writing in their classrooms. One college math teacher, working collaboratively with a composition instructor, had his students submit written explanations of the Fibonacci sequence. These written explanations were given to eight volunteer students in a second semester writing course. These English students had just written and revised papers that required them to show the steps in a process. The students responded in writing to the explanations the math students had written. These student respondents found that the math explanations were mixed; some moved too quickly and some walked them slowly through the operation. The math teacher read these responses to his students' papers and, in some cases, extended and qualified their remarks. Both the math and English teacher felt that this was a useful exercise (Forman, 1980).

Other math teachers have reported using writing to help teach their subject matter. In a 1978 report of the Wisconsin Writing Project, teacher participants in the summer institute created writing assignments for use in a variety of subject areas. Among these are three math assignments which are representative of the type of math done in grades 1 to 12. These examples include: writing story problems, explaining a magic number square and classifying and explaining several number systems (Smelston, 1978).

Another mathematics educator explains how she used writing to help students in a second year algebra class. After the teacher explained how to solve a quadratic equation, she asked the class to write a paragraph in their journals explaining how to complete the sequence. She collected the journals, wrote personal comments on them, and returned them. After reviewing the lesson, she again asked the students to write in their journals. They were asked to complete the following statement, "The problem I had with completing the sequence was . . .". She found that many of their math grades improved after keeping journals, and many of her students were enthusiastic about it (Watson, 1980).

In her doctoral dissertation study on writing as a tool for learning, Goodkin (1982) reports that community college math students who verbalized their difficulties in writing were often able to understand and solve problems that they could not solve before.

William E. Geeslin of the University of New Hampshire found that most math students can repeat on a test a definition; yet they cannot explain how two concepts are related.

They have difficulty writing mathematically correct statements. He concludes that, "based on past experience and observation of mathematics classes, it seems reasonable that poor performance is due partly to the small amount of experience that students have in writing about mathematics; primarily they are asked to 'get the answer' or 'prove the theorem'" (Geeslin, 1977, p. 112). Geeslin calls for more practice in writing about math and concludes, "It is our belief that writing about mathematics is useful both as a disagnostic tool for the teacher and as a learning device for the students" (p. 113).

He suggests that because writing about mathematics is a new experience for most students, the teacher should start with simple writing assignments, explaining a single concept in one paragraph. Using this suggestion, Geeslin found that "this practice appears to improve student learning and performance on traditional tasks" (p. 116).

As Whimbey notes in an article on problem-solving "the activities of skilled reasoning are generally carried out inside one's head. This makes it difficult for a teacher to teach and for a learner to learn. To teach something we would like it out in the open where both teacher and student can see it." He goes on to suggest that "one solution to this dilemma is to have both students and teachers think aloud as they work through ideas" (Whimbey, 1977, p. 257). Writing thoughts out as they work through ideas would be another alternative.

These investigators agree that writing can be an important tool for learning and believe that it can be an instrument in getting students to spend time thinking productively about the problems they are solving and the concepts they illustrate. The purpose of this present study is to ascertain the relative effectiveness of writing assignments as compared to traditional math assignments in an elementary algebra course for college students.

METHOD

During the fall of 1983, 83 students placed in four sections of an elementary algebra course at a large eastern state university were randomly assigned to either the experimental or control treatment groups.

TREATMENTS

The treatments consisted of fifteen assignments given to students over the course of the fall semester. The control (C) Treatment assignments ranged from 15 to 25 excercises on algebraic topics previously covered by class lectures. The experimental (E) treatment assignments were comprised of questions on algebraic concepts requiring written responses in paragraph form in addition to excercises covering the concepts in question (see appendix A).

Both E and C assignments were matched in terms of concepts covered and assigned to students at the same time the exercises given in the E assignment were identical to about one-half to two thirds of the excercises given in the C assignments. This was done to control for time spent on assignments.

In order to keep the three teachers from knowing to which group the individual students were assigned, the investigators folded the assignments so that only a blank page was revealed and the student's name was placed on the blank side. Teachers were also instructed not to answer questions regarding the writing portion of the experimental assignment until after all the reworked assignments were returned. Teachers would receive the folded assignments before classes began, and they would give the assignments out to students at the end of the class period. Students were required to complete and return the assignments to the teacher at the next scheduled class meeting, usually two days later. The teachers would put the assignments in an envelope and return the envelope to the investigator. Assignments were graded and returned to the students at the next scheduled class meeting. Students who did not receive full credit for an assignment were given a few days to rework the assignment and return the reworked assignment for more credit.

The assignments were counted as part of the student's homework grade for the course. Since homework only contributes a small portion of the student's final course grade, it was assumed that most students would not complete all homework assignments. Therefore, it was decided that the criterion used to determine whether students were participants in either group would be completion of two-thirds of the assignments. For the transfer quiz given during the fourth week of the experiment, students were considered as participants if they had completed four of the six assignments given before the quiz: For the performance test given at the end of the term, students were considered as participants if they had completed ten out of fifteen assignments given during the term.

INSTRUMENTS

Students were placed in the elementary algebra courses based on their performance on a thirty-one item departmental algebra placement exam (P) reliability (coefficient α) for this test was .87 for all freshmen tested during the summer of 1982.

During the fourth week of the term, all students were given a quiz consisting of six problems (T). The six problems required students to generalize their algebraic skills to other problems.

At the end of the course, all students took a comprehensive final exam. This exam was employed as a performance measure for this study (F). Final exams for all the elementary algebra sections (16 sections in all) were grouped together and graded impartially by all math teachers.

ANALYSIS

All students placed in the experimental and control groups scored between 6 and 12 on the departmental placement test (P). Nevertheless, a t- test would be employed to determine if significant differences between experimental and control subjects did exist. In addition, t- tests were also planned to determine if significant differences between experimental and control groups of students exist for T and F measures on appropriate participants.

RESULTS

Tables 1 and 2 contain the mean T and F scores for all students in the experimental (E) and control (C) groups with placement test scores. Analysis was conducted only on data appearing in the last row of both tables.

Insert Table 1 and Table 2
about here

Of the 83 subjects assigned to the experimental and control treatments, 16 students transferred or withdrew from classes before the fourth week leaving 67 potential participants. Of the 67 remaining participants, 43 of these taking the T quiz reached the criterion and were, therefore, considered participants. There were no significant differences between groups on either the P or the T measures (as indicated in Table 3).

Insert Table 3 about here

Of the 67 potential participants, only 26 reached the criterion of ten out of fifteen assignments completed, and, therefore, were considered as participants. The data for this group is present in Table 4. Again, no significant differences were found between groups on either P or F measures.

Insert Table 4 about here

For each group, Pearson correlation coefficients (r) were computed between the number of assignments completed (NAS) and the post-test measure (F). For 28 of the experimental students with F scores, the correlation was $r = .56$; for 29 control students with F scores, r=.51. Both correlations r were significant between the number of assignments completed and F for both groups. No significant differences were found between the experimental and control correlations.

DISCUSSION

The purpose of this study was to quantatively investigate the relative effects of writing assignments on math performance. The fact that the writing (experimental) assignments were found to be no more effective than the math-only (control) assignments, does not preclude writing as a useful tool for learning mathematics. This study looked at only one particular type of writing assignments under specific conditions. In an effort to control for teacher differences and to measure just the effects of the assignments, teachers were instructed to be non-directive for the writing assignments. Teachers were not permitted to comment on the assignments or answer questions about them. The assignments were, in fact, graded not by the classroom teacher but by an outside grader; therefore, neither teacher nor student viewed writing as an integral part of the math class. In addition, since math students are not accustomed to writing in a math class, they question the purpose of the assignments. As one student wrote on her paper, "This is a math class, not an English class!" The teacher who was instructed to be non-directive for the writing assignments did not have the opportunity to respond to this. If teachers are going to use writing assignments, they must integrate them into the math class.

The control (math-only) assignments were also affected by the fact that they were not viewed as an integral part of the math class. Both the experimental and control groups had a large amount of attrition, although it was lower for the control group. This may be explained by the fact that math students are accustomed to solving math problems, but they are not accustomed to answering questions verbally about mathematical concepts.

Post hoc analysis revealed that of all the students taking the final exam, significant correlations were found for both groups between the number of assignments completed and performance as measured by the final exam (F), i.e. the more assignments completed, the higher the level of performance on exams. No significant differences between coefficients computed on both correlation groups indicates that the writing assignments act similarly to the math-only assignments with respect to performance.

Thus, although there were no statistically significant differences between the experimental (writing) groups and control (math-only) group, both groups showed an increase in performance. And although the experimental students completed fewer traditional math problems than the control students, their performance was not affected detrimentally.

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Table 1

Mean Placement (P) and Quiz (T) Scores For The Experimental and Control Groups by Number of Assignments Completed

	P		T	
	E	C	E	C
0-3 Assignments Completed	8.86 n=7	9.75 n=4	1.14 n=7	.75 n=4
4-6 Assignments Completed	10.21 n=19	10.46 n=24	2.42 n=19	2.58 n=24

Table 2

Mean Placement (P) and Final Exam (F) Scores for the Experimental and Control Groups by Number of Assignments Completed

	P		F	
	E	C	E	C
0-9 Assignments Completed	10.06 n=17	10.43 n=14	52.4 n=17	54.6 n=14
10-15 Assignments Completed	10.27 n=11	10.47 n=15	74.36 n=11	69.47 n=15

Table 3

Mean Placement (P) and Transfer (T) Scores for the Experimental (E) and Control (C) Group Participants

	E n=19	C n=24	t
P	$\bar{P}$=10.21 S.D.=1.96	$\bar{P}$=10.46 S.D.=2.32	.372 (p=.711)
T	$\bar{T}$=2.42 S.D.=1.30	$\bar{T}$=2.58 S.D.=1.47	.377 (p=.708)

Table 4

Mean Placement (P) and Final Exam (F) Scores for
The Experimental (E) and Control (C) Group Participants

	E n=11	C n=15	t
P	$\bar{P}$=10.27 S.D.=1.95	$\bar{P}$=10.47 S.D.=2.47	.22 (p=.828)
F	$\bar{F}$=74.36 S.D.=12.3	$\bar{F}$=69.47 S.D.=18.34	.776 (p=.445)

Appendix A

Sample Writing Assignments for Experimental Groups

1. In your own words, explain what a least common multiple is.
2. Given two numbers, A and B, will the product of A and B always give you the least common multiple of A & B. Why or why not?
3. What is the difference between:
   a) $16 \div 8.2$ and $16 \div (8 \cdot 2)$
4. Given the statement:
   "Sam has 5 more dollars than Carol."
   If S= Sam's dollars and
   C= Carol's dollars
   Discuss whether S=5C is a true representation of the above statement. If the equation is not a true representation, how would you rephrase the <u>statement</u> to accurately reflect the equation?
5. State, in your own words, the meaning of the absolute value of a number.
6. In your own words, how do we define subtraction of signed numbers?
7. In words, describe the graph of X=-2.
8. A student was given the following two problems:
   Simplify the following:

   a) $\dfrac{x^2+y^2}{x}$

   b) $\dfrac{x^2-y^2}{x+y}$

The student turned in the following solutions:

$$\frac{\overset{x}{\cancel{x^2}}+y^2}{\underset{1}{\cancel{x}}} = x + y^2$$

$$\frac{\overset{x}{\cancel{x^2}}-\overset{y}{\cancel{y^2}}}{\underset{1}{\cancel{x}}+\underset{1}{\cancel{y}}} = x - y$$

In a paragraph, first explain what the student did to solve the problems, and then explain what was wrong or right with the solutions and why.

9. Given the two problems:

solve: $\frac{3}{x} + \frac{2}{x+1} = 5$

simplify: $\frac{3}{x} + \frac{2}{x+1}$

Do not solve:

Explain the differences between the two types of problems. Discuss the ways they should be solved.

10. Given the following, comment on what step (if any) is incorrect.

$5-3(x-4) = 2(x-4) = 2x-8$

11. What does $\sqrt{3}$ mean?

12. What property allows you to take the following step?

$(3x+2)(x-2) = 0 \rightarrow \begin{cases} 3x+2=0 \\ x-2=0 \end{cases}$

13. Discuss what is wrong with the following

a) $(x-2)(x+3) = 4 \longrightarrow \begin{cases} x-2=4 \longrightarrow x=6 \\ x+3=0 \longrightarrow x=-3 \end{cases}$

b) $(2x-3)(x+2) = 0 \longrightarrow \begin{cases} x=-2 \\ x=-3/2 \end{cases}$