To the Graduate Council:

I am submitting herewith a dissertation written by Joan E. Henn entitled "The Effect of Journal Writing on the Learning of Mathematical Concepts and Problem Solving Skills by Preservice Elementary Teachers at the University of Tennessee, Knoxville." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

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THE EFFECT OF JOURNAL WRITING ON THE LEARNING OF MATHEMATICAL CONCEPTS AND PROBLEM SOLVING SKILLS BY PRESERVICE ELEMENTARY TEACHERS AT THE UNIVERSITY OF TENNESSEE, KNOXVILLE

A Dissertation

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ABSTRACT

Elementary school teachers play a critical role in the development of their students' mathematical abilities. Therefore it is of vital importance that they are competent in the mathematics of the elementary school. However, many prospective elementary teachers view mathematics as a very difficult subject and have little confidence in their ability.

This experimental study examined the effects of journal writing as a means of learning mathematical concepts and improving the problem solving skills of preservice elementary teachers enrolled in "Structure of the Number System," at the University of Tennessee, Knoxville. The study was done in two parts. The first was a short term study of one quarter duration. The second part was a long-term study which examined the work of those students who remained in the same treatment group for a second quarter. A problem-solving pretest was given at the beginning of the study. Each quarter, the students took three mathematical content examinations and a problem-solving posttest. The mean scores of the experimental group and the control group were compared using independent means t-tests.

Students in the experimental class were given eighteen open-ended journal writing assignments each quarter. The topics included mathematical concepts, attitudes, goal

setting, and reflection upon previous work. Students in the control class were given a quiz over the homework every Friday. The same lecture was presented to both groups and both groups were assigned the same homework.

The study showed no significant differences ($p < .05$) between mean scores of the experimental group and the control group on either the problem-solving posttest or the mathematical content examinations.

Student reactions were positive. The students indicated that journal writing helped them to understand mathematical content, helped to relieve anxiety and frustration, and improved their relationship with the instructor.

Results of this study indicated that journal writing in a mathematics class of preservice elementary teachers was as effective as weekly quizzes in preparing the students for mathematical content examinations while eliminating the anxiety and pressure that many of the students associated with a weekly quiz.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The National Council of Teachers of Mathematics has recommended in both the Agenda for Action (1980) and the Curriculum and Evaluation Standards for School Mathematics (1989) that problem solving be the focus of the mathematics curriculum in the elementary school. For this to happen, the elementary teachers need to be comfortable with mathematics and enthusiastic about problem solving. This may necessitate a major change in attitude for many preservice elementary teachers who begin their training with negative attitudes toward mathematics and a very real fear of word problems (Bulmahn & Young, 1982).

In the typical mathematics class for preservice elementary teachers, the instructor furnishes everything--the topic, examples, explanations, rules and algorithms. This leads to dependence on the part of the student, eliminates the need to think for oneself, and encourages learned helplessness. Students become so used to receptive learning that they cannot trust their own intuition or believe that they can learn from their own experience (Blais, 1988; Boreham, 1987). But it is only when a student becomes actively engaged in the learning process that learning occurs (Bruner, 1979; Whitehead, 1929; Yinger, 1981).

Researchers (Britton, 1970; Emig,1977; Flower & Hayes, 1980; Fulwiler, 1981; Pea, 1987; Yinger, 1981) have suggested that writing is one way of getting students actively involved in the learning process. In this study, the use of journal writing was examined as a means of enhancing the learning of mathematics and increasing the problem solving ability of preservice elementary teachers. There were four types of writing assignments given (in addition to daily homework): explanatory or descriptive writing, affective writing, writing to set goals, and writing to reflect upon previous activities. The students were encouraged to experiment, to ask questions and to make comments.

Background of the Study

The basic premise of this study is that writing is an interactive process in which a person draws upon his personal experience to assimilate new information in such a way that will improve learning and problem solving ability.

The theoretical basis used is constructivism, the roots of which go back to the eighteenth century philosopher Immanuel Kant, who considered knowledge to be the invention of an active person interacting with the environment (Efran, Lukens & Lukens, 1988). According to this theory, knowledge cannot be simply transmitted from one person to another through telling or explaining; each person must discover,

invent or construct it for himself (Piaget, 1973, Lochhead, 1985, Blais, 1988).

The model to be used is that of Andre and Phye which was influenced by the work of Attkinson and Shriffrin (1968). This model portrays the mind as an information processor which consists of input and output buffers, short-term and long-term memory, and an executive that keeps track of the information being processed and controls it's flow (Andre & Phye, 1986).

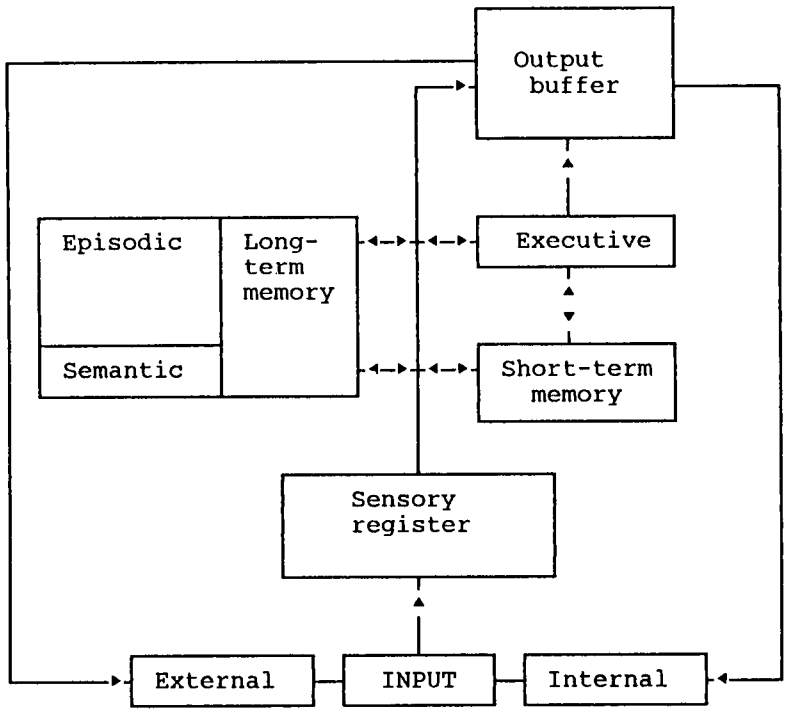

Figure 1. Learning Model of Andre and Phye

The input buffers, also called the sensory registers, are very short-term memories associated with the senses that hold incoming information until it can be processed (Andre & Phye, 1986).

The short-term memory contains information currently being thought about and processed. Estimates of its capacity range from two to seven "chunks" of information at any one time and unless this information is continuously thought about or refreshed, it is very rapidly lost from short-term memory. All incoming information must come in through short-term memory if it is to be learned. If it is presented too fast, the short-term memory cannot process it quickly enough and information is lost (Andre & Phye, 1986).

There are no such limits to long-term memory. It has random access and is content addressable. The two kinds of long-term memory are episodic memory which records experiences or events in one's life, and semantic memory which records organized knowledge, rules, relationships, word meanings, etc. (Andre & Phye, 1986). To think about something it must first be found in long-term memory and then transferred to short-term memory. But again, only a limited number of "chunks" of information can be transferred from long-term memory into short-term memory (Davis, 1984).

The executive controls the flow of information as it is being processed. It determines priorities based upon the capacity of the system and person's goals and motivations. The output buffers are thought to be responsible for automated procedures such as driving a car or riding a bicycle that do not require our conscious attention (Andre & Phye, 1986).

In learning we must start from our own personal experience. We must accept and build upon our present understandings. Learners reorganize new information through an interaction with present understandings in such a way as to construct knowledge (Silver, 1987; Torbe, 1986). As Blais (1988) put it, "Constructivism . . . does not say that knowledge is something that learners ought to construct for and by themselves. Rather, it says that knowledge is something that learners must construct for and by themselves" (p. 626-627). While teachers and texts give information, the words and sentences do not contain any fixed meaning. Cassirer (1953) called this an "inherent weakness of language" (p. 4). Language is essentially ambiguous. Therefore students must interpret information for themselves in light of their own knowledge base and thus construct a meaning (Kulhavy, Schwartz, & Peterson, 1986; Royer, 1986). Andre and Phye (1986) assert that what a student acquires from instruction is determined as much by what the he already knows as by the nature of the instruction.

It is only when new information has been integrated in a meaningful way into the learner's existing knowledge structure that it is understood. If the student does not have any relevant knowledge, then memorization may occur, but learning will not (Royer, 1986). Even under the best of conditions the learner's meaning will necessarily deviate to

some degree from the meaning actually presented. The learner not only interprets, he adds new information, simplifies it, embellishes it, and creates inferences about it to make it fit with his own knowledge base (Gagne, 1975; Kulhavy, Schwartz, & Peterson, 1986; Olson, 1977). Knowledge that is not integrated into our knowledge structure is quickly forgotten (Barnes, 1986).

Statement of the Problem

Can the learning of mathematical concepts and problem solving skills in a course for preservice elementary teachers be enhanced by the use of journal writing assignments in place of the usual content quizzes?

Importance of the Problem

Elementary school teachers play a critical role in the development of their students' mathematical abilities. Therefore, it is of vital importance that they are competent in the mathematics of the elementary school. They must know, understand, and be able to explain mathematics that is substantially beyond what they are required to teach (Dossey, 1988; Isenberg & Altizer-Tuning, 1988; National Council of Teachers of Mathematics, 1980).

However, many prospective elementary teachers view mathematics as a very difficult subject and have little confidence in their ability. Teacher education programs need

to encourage the students to think and use their own ideas in such a way that they will develop confidence and competence so that they can teach mathematics in a meaningful and appropriate way (Isenberg & Altizer-Tuning, 1988).

Research suggests that the use of writing in mathematics will improve learning and understanding of content areas as well as boost confidence in problem solving ability (Odell, 1980; Selfe, Peterson, & Nahrgang, 1986; Yinger, 1981). Writing can enhance learning by increasing the depth of processing thus causing the memory to elaborate upon the information (Yinger, 1981). Writing is active, purposeful and personal. The writer searches the memory, wrestling with his thoughts if he needs to, as he forms new concepts and ideas (Britton, 1970; Flower & Hayes, 1981). Vygotsky (1962) called this process "deliberate structuring of the web of meaning" (p. 100). Writing demands an organization and explicitness that leads to more effective learning.

Research Hypotheses

This study was designed to investigate the effectiveness of writing as a tool in the learning of mathematics concepts and problem solving skills by preservice elementary teachers.

The following null hypotheses were tested for both the short term and the long term study:

H1: There is no significant difference between the means of the scores on the problem-solving posttest of the experimental group and the control group.

H2: There is no significant difference between the means of the scores on each of the teacher-made content examinations of the experimental group and the control group.

The following null hypotheses were tested for the short term study only:

H3: There is no significant difference between the means of the scores on the problem solving posttest of the above average writers and the entire control group.

H4: There is no significant difference between the means of the scores on each of the teacher-made content examinations of the above average writers and the entire control group.

H5: There is no significant difference between the means of the scores on the problem solving posttest of the below average writers and the entire control group.

H6: There is no significant difference between the means of the scores on each of the teacher-made content examinations of the below average writers and the entire control group.

CHAPTER II

REVIEW OF LITERATURE

This chapter has two parts. The first part briefly discusses the philosophical and theoretical framework surrounding the write-to-learn movement. The second part looks at research in the area of writing to learn.

Writing and Learning

Although the writing-to-learn movement is comparatively new, theorists have considered the relationship between language, including writing, and learning for centuries. Socrates soundly denounced the use of writing, saying that those who write "will cease to exercise their memory and become forgetful; they will rely on writing to bring things to remembrance by external signs instead of on their own internal resources" (Plato, 1973, 275).

Modern theorists strongly disagree. The eminent Russian researcher and psychologist Lev Vygotsky (1962) said that "thought is born through words. . . . a thought unembodied in words remains a shadow" (p. 153). He stressed that it is only through language, and particularly through writing, that a child fully develops higher levels of abstraction.

Janet Emig (1977) of Rutgers University has done extensive research on the composing processes of student writers. She believes that "writing is a unique mode of

learning--not merely valuable, not merely special, but unique" (p. 122). In her influential essay, "Writing As a Mode of Learning," she discusses the relationships between writing and learning. In writing, thoughts can be reviewed, modified and expanded, because they become visible and concrete. Writing, like successful learning, is an active, engaging and personal act which provides a unique form of feedback and reinforcement.

Learning is more than passive absorption. Many times, the students already have some prior knowledge with which to assimilate new material and construct their own meanings. In the Curriculum and Evaluation Standards for School Mathematics, the National Council of Teachers of Mathematics (1989) recognizes this constructive view of learning and recommends the use of writing. Specifically, this report states, "Writing about mathematics . . . helps students clarify their thinking and develop deeper understanding" (p. 26). And "Opportunities to explain, conjecture, and defend one's ideas . . . in writing can stimulate deeper understandings of concepts and principles" (p. 78). This report also suggests that writing can be used to explain how a problem was worked through, to help clarify the student's thinking and to encourage reflection upon learning. Also, students' writing can give the teacher valuable information about their understanding.

Synthesis of Related Research

While there has been research for many years in the areas of writing and learning as distinct and separate processes, research in the area of using writing as a learning tool is relatively recent. The research seems to fall into four very general categories. This review will begin by examining studies of the attitudes of teachers and students toward both writing as a mode of learning and using writing to influence the attitudes of the students about the subject matter. Attention is then given to studies of the effectiveness of various types of writing. Next is a discussion of research on the differences among writers which may determine the effectiveness of their writing as a mode of learning. Finally, there is a look at studies of writing as a means of learning course content and acquiring problem-solving skills.

Attitudes of Teachers and Students

A sometimes unexpected benefit of writing in the classroom is the insight gained by teachers. Teachers at Michigan State University reported, after a study using journal writing in ten sections of an introductory educational psychology class, that they had gained valuable insights into their teaching (Clark, 1981). A teacher of civil engineering at Michigan Technological University said

that as a result of using journals in his classes, he gained a new perspective on student learning, on his teaching and on the goals of the course--a perspective which challenged him and reinvigorated his thinking (Young, 1985). Richard Mason (1987) maintained that his students' writings gave him new insight into their thoughts and feelings. Occasionally these insights can be unpleasant, when the writings show that the students are confused or have learned less than the teacher had hoped. But more often they are rewarding, when they show that the student's learning has advanced beyond rote memorization (Drenk, 1982).

Surveys of teachers and students will often show that although it hasn't been proven, they believe that writing improves thinking and reasoning skills. For example, Gail Hearn of Beaver College stops lecturing when she sees a sea of blank faces in her biology classes and asks her students to write for five minutes about the subject on which she has been speaking. She believes that the written summaries help the students to think better (Palmer, 1983). Anne Wotring, a consultant to the Northern Virginia Writing Project, concluded that writing in a chemistry class helped to clear up confusion, to promote understanding, and to help students accept responsibility for their own learning (Goodkin, 1982/1983).

At the University of Tennessee, faculty and student response to a writing program was very favorable. The

subjects indicated that the writing assignments were useful; writing helped the students to better focus on the class topics and to think more effectively about ideas (Bensel-Meyers & Samson 1988).

Though the conclusions of these faculty members are interesting, they are subjective and difficult to support.

The National Council of Teachers of Mathematics (1989) maintains that if students write about the frustrations which they encounter in their work, they can often find ways to overcome these frustrations, and that they often develop more positive attitudes about what they are doing. This theory was supported by a study conducted in a psychology class at the University of Michigan, where writing was tried as a way to reduce anxiety and its negative effects upon problem solving. The researchers found that encouraging students to write comments about test questions which they felt were vague or misleading helped them to improve their scores (Anderson & Fause, 1973).

Another study which indicated that writing may improve student attitudes was done by Janet Swaby (1987) of Indian Hills Community College in Ottumwa, Iowa. She found that when she used writing in her basic algebra class, the attrition rate dropped from 22% to 14%. However, the fact that she was comparing a summer school class with her other classes during the past year may account for some of the

differences in the attrition rates, and must taken into consideration when interpreting the results.

Carol Ropp (1989) administered an attitudinal survey at the beginning and end of a semester in order to determine how students felt about using writing to learn in her high school geometry classes. She used two types of writing. One was a short answer format that allowed her to quickly determine the level of her students' understanding. The other was open-ended journal writing. At the end of the semester, she reported a 200% increase in the number of students who said that journals helped them to think about what they learned and a 230% increase in the number of students who said that journals helped them to "discover new ideas about the topics covered in class" (p. 13). It is not clear exactly what this means, however, because the report told only the percentage of increase, not the percentage of the students who found writing useful the first place.

Types of Writing

Forty-five students at the Center for Research in Writing at Brown University were each given fourteen controlled writing assignments. In each assignment, the students were told to define some relationship within a set of information fragments, write a paragraph based upon this relationship, and then to summarize the paragraph in one sentence. Approximately 85% of the summaries contained new

information that went beyond the original relationship that was stated, suggesting that writing as little as one paragraph can lead the writer to a new awareness of relationships (Van Nostrand, 1979).

George Newell (1984) examined the use of different types of writing in order to determine their effects upon learning. During a series of six sessions, eight eleventh grade students who possessed high reading and writing ability were given prose passages in science and social studies. In each session they were asked either to answer study questions which would help them prepare for a test, to take notes as they usually did when studying for a test, or to write an analytical essay in which they applied the concepts from the passages to a new situation. He found that the students learned more science and social studies concepts when they wrote essays than when they took notes or answered study questions. Newell suggested that this was because the essay writing required "more extensive thought and consideration of content" (p. 282).

Judith Langer (1986) conducted a similar study with six high school juniors in social studies. By analyzing think-aloud protocols, Langer found that when writing essays, the students thought about almost twice as many ideas as they did when taking notes or answering study questions. They did more integration and evaluation of the ideas that they were considering. On a relayed recall test,

it was found that topic knowledge increased far more when doing essay writing than when taking notes or answering study questions.

A descriptive study of the use of journals in civil engineering classes at Michigan Technological University was conducted in 1981 to determine whether or not writing was effective as a learning tool. It focused on the role of journal writing in student learning, preparing student reports, and student-teacher interaction. The final reports of students in the experimental group were judged by the researchers to be more coherent, organized, and complete than those reports written by students in a control class. The researchers also concluded that using journals provided a way for the students to effectively communicate with the teacher: they could give more complete information about methods they used to solve problems, and they were also more likely to cultivate a positive rapport with the instructor than were those students in the control class (Selfe and Arbabi, 1986; Young, 1985).

Sandra Lawrence (1988/1989) of Harvard University, however, found that journals were not effective for all students. In a study of journal writing in two community college classrooms, Lawrence found that although some students found journal writing to be an effective learning tool, many either did not do the assignments or handed in incomplete, last minute efforts. Through data collected from

classroom observations and personal interviews, Lawrence found that instructions for the journal assignments were given only once or twice during the semester and the journals were collected only two or three times, leading many students to believe that they were "just another assignment to complete" (p. 284), and to assign them a low priority status. Lawrence concluded that if journals are to be effective as learning tools, there must be "careful planning, clear instructions, and well-articulated expectations for learning" (p. 287).

A descriptive case study done at Michigan Technological University analyzed all the writing done by five engineering students during their four or more years there. Fifty-three percent of the writing consisted of laboratory reports. However, a questionnaire revealed that, although the students valued writing, they did not view it as a way to learn engineering skills. As a result of this study, one science teacher began using logs instead of lab reports and reported that class performance improved because the logs helped to organize the problem solving procedure (Kalmbach, 1986).

Harry Robertshaw of Virginia Polytechnic Institute and State University was disturbed by lab reports that were unorganized and lacked focus. After attending a writing institute, he reorganized his assignments and grading criteria. He found that his students produced reports that

were more interesting, more imaginative and better organized. He also reported that the improvement continued as the students moved into more advanced courses (Thaiss, 1982).

Two studies suggest that keeping journals is beneficial to preservice teachers. The first was done with two groups over a period of two terms at Michigan State University in an introductory educational psychology course in 1981. A questionnaire given at the end of each term indicated that the students found journal writing useful in relating the course content to their experiences outside of class (Clark, 1981).

A second study by Glassberg and B. J. Benham suggests that using a dialogue journal technique to communicate with the preservice teachers as they do their student teaching can be an effective addition to supervision. They concluded that if the students were already accustomed to writing in their methods classes, the habit of thinking through writing combined with their earlier journal entries could help to bridge the gap between theory and practice, and could also make the students aware of their progress (Clark, 1981).

Differences in Writers

A few studies analyzed differences between good writers and poor writers. In a study which used students from the fifth grade through the first year of college and evaluated

their ability to write summaries of stories, Brown, Day, and Jones (1983) found that the better writers were more likely to abstract the main ideas and restate them in their own words but that the poorer writers would proceed sequentially through the text and decide for each item whether to delete it or copy it verbatim. Katheleen Copeland found that there was little difference in the scores of good writers and poor writers on tests of factual recall, but the better writers were much better in applying the information to new situations (Penrose, 1986).

Gerald Burton (1986/1987) in a study of students enrolled in basic mathematics classes at Virginia State University found that, in general, writing essays in a basic college mathematics class does not improve content learning or problem solving ability. However, when he analyzed the results by writing level, he found that the good writers showed higher achievement than the poor writers and those students who did not write at all, on almost every measurement. There were limitations to this study, however. The experiment lasted only four weeks, and Burton expressed doubt that the five application problems on the multiple-choice posttest adequately measured problem solving ability.

At Gallaudet College an interesting thing occurred in a computer literacy course. The students in the experimental section were to explain their programs in writing, but those

with the worst English skills, who were also the worst programmers, refused to do so. The result was that those who were expected to benefit the most from the writing did not participate (Kelly, 1985).

When Ann Penrose (1986) asked students to think aloud while writing a report based upon a short passage about hurricanes, she found that there are also differences between good writers. Some paraphrased the text a sentence or two at a time, while others looked for main ideas, summarized, and discussed the implications. Students in both groups scored about the same on tests of recall but those in the second group did much better on questions which required the student to draw inferences or to synthesize the information. She concluded that what students learn as they write depends upon what they do when they write. Therefore, it is her opinion that writing is not necessarily going to enhance learning for every student in every situation.

Ronald Bell (1987/1988) found similar results. In his study of the use of expository writing to teach thinking skills and geometry to high school students, he concluded that writing was beneficial to individual students, but not to everyone in the group, indicating that writing in mathematics must be "streamlined to the needs of the students and teachers so that the highest degree of benefit can be derived by the greatest number of students" (p. 66).

Francelia Clark (1987) found similar results in her research. After a review of impromptu essays written by superior students at the University of Michigan, Clark found that if writing is to be valuable as a mode of learning it must be an integral part of the course. If it is merely an add-on it is perceived as an extra burden and is resented. This is consistent with Art Young's (1985) findings. Upon finishing his research at Michigan Technological University, he concluded that for journals and other types of speculative writing to be effective, they must be closely integrated into the course goals.

Content and Problem Solving Skills

Studies which show significant improvement in content areas are few, and usually not very scientific. For example, Margaret Watson (1980) of Duncan High School in Duncan, Oklahoma, reported that when she used journal writing in her algebra 2 class that many of their grades "improved" (p. 519).

Swaby (1987) encouraged her students in a remedial algebra class to use a different color ink to write notes and questions to themselves each time they made a discovery or had a problem as they did their homework. She found that the students thought the problems through more carefully and asked questions of a higher quality than students of previous classes. Test results were outstanding--the class

average was 15 points higher than the average for the three other basic algebra classes that she had that year. However, Swaby did point out that the class was a small summer school class composed primarily of nontraditional students who are often more highly motivated than average. This must be taken into consideration when interpreting the results.

At George Mason University, Minja Paik experimented with journal writing in two of her statistics classes, using volunteers. The students in the experimental group kept journals in which they summarized material after class. They also used writing to try out solutions and to identify problems in their understanding. She reported that the students in the experimental group "scored a statistically significant average of 15 percent higher on tests than students who did not keep journals" (Thaiss, 1982, p. 45). As has been previously discussed, there is evidence to suggest that writing benefits some students more than others. Consequently, the use of volunteers in the experimental group may have affected these results.

A study was conducted at Gallaudet College to determine if writing activities could improve content learning and enhance literacy among deaf students. Seven instructors participated in the study. Because of the unique English language deficiencies associated with deafness, some of the instructors focused very intensively on grammar and writing skill development. Because these skills are so resistant to

change, and because some teachers did not systematically measure the effect on content learning, some of the instructors were not sure that writing was effective, especially with the most unskilled writers (Kelly, 1985).

One exception worth mentioning is Russell Olson. In his course, "Presidential Election 1984," he assigned summaries of newspaper articles from the beginning of the term until the election in November. His students also wrote a term paper. To evaluate the effect of writing, his examinations were in two parts. One part included test items that covered material about which the students had written. The other part covered material in the course about which the students had not written. The scores on the writing supported test items averaged 11% higher than the test items not supported by writing (Kelly, 1985).

The Gallaudet students responding to a questionnaire indicated that they found writing helpful both in learning literacy skills and in understanding course content. Seventy-five percent said that they would like to have writing assignments in other courses, and all of them agreed that writing helped them to better organize ideas, to focus on the most important part of their reading, and to learn. Faculty members indicated that students' writing made them more aware of students' strengths and weaknesses and more sensitive to their level of competence (Kelly, 1985).

A study conducted at West Chester State College in Pennsylvania in 1979 was carefully designed. It observed the use of writing in four different content areas: a graduate reading course, a graduate research and statistics course, an undergraduate course in educational psychology and a large lecture section in physical science. The experimental group in each area was given a variety of writing assignments plus two questions which were to be answered at the end of each class period: "Which concept dealt with in today's class is most clear? Which is least clear?" (p. 3). Content learning was higher in each of the experimental groups, but an analysis of variance showed that it was significantly higher in only the statistics classes (Weiss & Walters, 1980).

There are a few studies that focus on learning content in a mathematics class. William Geeslin (1977) investigated the use of writing in teaching elementary probability to students in grades four through twelve. In addition to using a programmed text, the students were asked to write about the relationships between pairs of probability concepts. After two weeks, the tests showed that most of the students at all levels had mastered the probability concepts. However, in this and other studies, Geeslin has found that students of all grade levels have had little experience using writing in mathematics and generally do not do well on writing assignments. His studies indicate that it is only

with practice that students begin to slowly develop the skills necessary to write a complete and correct mathematical idea.

When Vera Goodkin (1982/1983) compared the writing done by students in a calculus class with the writing of students in a basic mathematics class, she found that students in the different classes used writing in different ways. The calculus students were more original and innovative as they searched for alternative methods to solve problems, but the basic mathematics students used writing to reinforce new knowledge. In both cases however, writing focused the students' minds on the problems at hand, thus helping them to learn.

Another study, conducted in 1981 at Michigan Technological University, tested the use of journal writing in three traditionally taught mathematics classes in an experimental study. One section wrote only speculative journal entries for homework. Another wrote journal entries and did numerical problems for homework, and the third did only numerical homework problems. All students took the same examinations. The study showed no difference in the performance of the three classes on the examinations. In this study, journals were as effective as homework problems in preparing students for a traditional numerical content examination (Young, 1985).

Another study at Michigan Technological University in 1983 was conducted with three sections of analytic geometry and calculus taught by teachers. One class was assigned a series of twenty journal entries. A second class took ten quizzes and the third class did neither. A study of the journals suggested that learning occurred through writing, and the teacher and most of the students felt that the journals were beneficial in helping to understand the mathematical concepts and solve math problems, but the quantifiable data did not prove this (Self, Peterson, & Nahrgang, 1986).

Journal writing has been suggested by the National Council of Teachers of Mathematics (1989) as a way to help students improve their problem solving skills. The processes involved in writing, such as brainstorming, revising, and reflection, can be helpful when solving mathematical problems. This exploratory use of writing encourages understanding as the students discover relationships between concepts so that they do not rely on rote memorization or mimicry (Barnes, 1986; Goodkin, 1982/1983).

Bell (1987/1988) found evidence to support this theory as he studied the use of expository writing to teach critical thinking skills and geometry to high school students. They were not researching problem solving ability and so it was not pretested. However, an unexpected result occurred when a significant difference was found between the

abilities of students in the experimental class and the students in the two control classes to solve a word problem that was on the nonverbal test of thinking skills given at the end of the study. He believes that it is possible that this increased ability to solve mathematical word problems was a result of the writing assignments given during the study.

Conclusion

Definitive results are very difficult to find. As Art Young and Toby Fulwiler (1986) said, "We don't know to date of any studies . . . which prove conclusively that writing improved learning--we are 'sure' that it does, but we're not sure it's been proven" (p. 138). Most of the literature indicates that those who have tried writing-to-learn activities believe that it works, despite the lack of quantifiable data. But more recent studies, such as those by Penrose (1986), Bell (1987), Clark (1987), and Lawrence (1988/1989) seem to suggest that, while writing can be very helpful for some students, it is not a panacea which works effectively for all students under all conditions. More research is needed in order to determine how writing assignments can be used to bring more thorough and consistent benefits.

CHAPTER III

GENERAL DESIGN

Journal writing was investigated as a means for preservice elementary teachers to learn mathematical knowledge and problem solving skills. The study was a pretest-posttest control group design with one control group and one experimental group.

Population and Sample

The target population for this study was a group of preservice elementary students enrolled in the mathematics course "Structure of the Number System" at the University of Tennessee, Knoxville. This course was a three-quarter sequence of basic mathematical concepts. The study was conducted during the second and third quarters of the academic year 1987-1988.

Two intact classes of Mathematics 2120 (Structure of the Number System) were selected for the study. One was used for the experimental group, and the other for the control group. During the first quarter of the study, there were forty-five students in the experimental class and forty-three students in the control class. However, four subjects in the experimental class and nine in the control class were eliminated from the study because they declined to take the problem solving pretest and posttest which were

not mandatory and were not used to determine their grades in the course. Because the mathematics ACT scores were being used in independent means t-tests to determine if there were any initial differences between the comparison groups, anyone who had not taken the ACT test was also eliminated from the study. Nine subjects in the experimental group and three in the control group were eliminated because they had not taken the mathematics ACT. These subjects were transfer or reentry students. Ninety-one percent of the experimental group and 97% of the control group were female.

To investigate the effects of journal writing over a longer period of time, data were also gathered during the following quarter using two classes of Mathematics 2130 (Structure of the Number System) containing some students who had been in the same treatment group during the previous quarter. There were thirteen students in the experimental group and nine in the control group of the long term study. All subjects in the experimental group were female. Eight of the nine students in the control group were female.

Instruments

During the first academic quarter, the following instruments were used:

1. A problem-solving pretest of four problems (see Appendix E).

2. A problem-solving posttest of four problems (see Appendix E).

3. Three teacher-made content examinations.

During the second academic quarter, the following instruments were used:

1. A problem-solving posttest of four problems (see Appendix E).

2. Three teacher-made content examinations.

The solutions to the problem-solving tests were evaluated using the "Focused Holistic Scoring Point Scale" from How to Evaluate Problem Solving by Charles, Lester, and O'Daffer (1987). It is a four-point scale that focuses on the total solution and the thinking processes implied by the answers instead of just the answers. The complete scale is in Appendix C. The tests were reviewed by a professor of mathematics at the University of Tennessee and judged to have content validity.

The content examinations were given after three weeks, after six weeks, and at the end of the quarter. The students had fifty minutes to complete each of the first two examinations and two hours to complete the third examination.

Procedure

The project began in January, 1988. Two intact classes of Mathematics 2120 (Structure of the Number System) were

selected for the study. Both were taught by the researcher. One was designated as the experimental group, the other the control group. A handout which explained the journals (see Appendix B) was distributed to the experimental class during the first class period. During the second week of the first quarter, a problem-solving pretest of four problems (see Appendix E) was administered. The students were allowed forty-five minutes to complete the test.

Throughout each quarter, both groups studied the same material and took the same content examinations. Classes met three times weekly for fifty minutes. The textbook used was A Problem Solving Approach to Mathematics for Elementary School Teachers, second edition, by Billstein, Libeskind, and Lott (1987). During the first quarter the content was taken from chapters five through nine and included number theory, rational numbers, probability, and statistics. The second quarter the content came from chapters ten through twelve and included Euclidean geometry and concepts of measurement. Content examinations were given at the end of the third and sixth weeks of the quarter. The students were given fifty minutes to complete each. A third examination was given during the formal examination period at the end of the nine week quarter. Students were given two hours to complete the examination.

Both classes were assigned the same homework from the textbook. Homework was not collected. The control group was

given a content quiz every Friday. The experimental group was not given quizzes but were required to write at least eighteen times each quarter. Specific journal writing assignments were given (see Appendix D), but the students were also encouraged to ask questions or to make comments in addition to the assigned topic. The journal assignments were mostly open-ended and covered four general areas: mathematical concepts, attitudes, goal setting, and reflection upon previous work.

The journals were collected seven times during each quarter and returned the next class period with the instructor's comments written in them. Feedback was designed to be positive and constructive, and did not correct grammatical or spelling errors unless they interfered with content. The journal assignments were graded on a credit/no credit basis.

If, while reading the journals, it became clear to the instructor that many students had similar misunderstandings concerning the course material, further feedback was provided. Sometimes a handout was prepared with the solutions to problems or answers to questions. At other times the topic was discussed further during the next class period. This additional information was not provided to control class because it was given in direct response to the journal writing.

During the ninth week of classes, a problem solving posttest was administered to both the experimental and control groups. The students had forty-five minutes to complete the test.

Data Analysis

Data collected for each subject included mathematics ACT scores, a problem solving pretest score, a problem solving posttest score and three content examination scores. Data for subjects in the experimental group also included the journals which the students submitted. The long term study data also included a second problem solving posttest score and three additional content examination scores. To determine if there were any initial differences in the students' mathematical knowledge or problem-solving ability, an independent means t-test was used to compare the means of those scores. Because the results showed no significant differences ($p < .05$), the problem-solving posttests and the content examinations were analyzed using an independent means t-test.

The journals were evaluated by a doctoral student in the English department at the University of Tennessee to determine the general writing ability of the students in the experimental group. They were divided into three groups: above average writers, average writers, and below average writers. Those rated as above average writers were those who

would have earned Bs or As in freshman composition. Those rated as average are typical of the average college student who would earn a C- to C+. Those rated as below average were those who, based on their journals, probably would not pass a composition course at the University of Tennessee. Because there were no writing samples from the control group, the students in the control group were not divided into groups based upon writing ability.

The data were then also analyzed on the basis of writing ability. The ACT scores, the problem-solving pretest scores, the problem-solving posttest scores, and the content examination scores of the above average writers in the experimental group were compared with those of the entire control group. Similarly, the ACT scores, the problem-solving pretest scores, the problem-solving posttest scores, and the content examination scores of the below average writers in the experimental group were compared with those of the entire control group.

The last journal assignment each quarter asked the open-ended question, "Please write about your reaction to writing a journal in a math class." The answers were analyzed to determine the students opinions about the usefulness of journal writing in helping them learn mathematical concepts and improve problem solving skills.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The purpose of this study was to determine the effect of journal writing on mathematical content learning and the development of problem solving ability in preservice elementary teachers. The study was done in two parts. The first was a study of nine weeks duration with two classes of preservice elementary teachers. The second was a study of eighteen weeks duration which followed the progress of a subset of the original groups of subjects for a second term.

This chapter contains the results of the statistical analysis of the data collected, organized according to the null hypotheses stated in Chapter I. The first section describes results of the short term study and the second section describes the results of the long term study. The final section contains a discussion of student reactions toward the journal writing assignments.

In the first section the means of the ACT scores, the problem-solving pretest scores, the problem-solving posttest scores, and the content examination scores of the following groups were compared: (1) the control group vs the experimental group, (2) the above average writers of the experimental group vs the entire control group and (3) the

below average writers of the experimental group vs the entire control group.

In the second section the means of the ACT scores, the problem-solving pretest scores, the problem-solving posttest scores, and the content examination scores of the control group and the experimental group were compared.

Short Term Study

Introduction

Because the subjects were not randomly selected for the study, an independent means t-test was performed on the mean ACT scores and the mean problem-solving pretest scores to determine if there were any initial differences in mathematical knowledge or problem solving ability of the two groups in each of the three areas of comparison. Because the mean scores of the groups were shown to be essentially the same in every instance, the means of the examination scores and problem-solving posttest scores were compared using an independent means t-test.

Control Group vs Experimental Group

The means of the ACT scores of the control group and the experimental group were not significantly different (see Table 1). The experimental group had higher mean scores on each of the content examinations than the control group, but

the mean scores were not significantly different at the $p < .05$ level. However, this does suggest that the writing of a journal prepared the students in the experimental class for content examinations as well as weekly quizzes.

TABLE 1

EXPERIMENTAL GROUP VS CONTROL GROUP
ACT MATHEMATICS SCORES AND PROBLEM-SOLVING PRETEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			EXPERIMENTAL GROUP			
	n	M	SD	n	M	SD	t
ACT	31	16.65	5.12	32	16.47	6.98	0.11
Pretest	31	7.55	2.58	32	8.75	3.33	1.60

Not significant at $p < .05$

There were no significant differences ($p < .05$) between the means of the problem solving posttest scores of the experimental and control groups (see Table 2).

TABLE 2

EXPERIMENTAL GROUP VS CONTROL GROUP
CONTENT EXAM SCORES AND PROBLEM-SOLVING POSTTEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			EXPERIMENTAL GROUP			
	n	M	SD	n	M	SD	t
Exam I	31	79.52	11.14	32	84.69	9.21	2.01 *
Exam II	31	84.32	13.87	32	86.59	13.73	0.65
Exam III	31	83.26	13.51	32	88.59	9.89	1.78
Posttest	31	9.55	1.82	32	10.19	1.64	1.46

* significant at $p < .05$

Above Average Writers vs Entire Control Group

There was no significant difference in the mean ACT scores of the above average writers in the experimental group and the students in the control group as determined by an independent means t-test (see Table 3). Although the actual means of the examination scores were consistently higher for the above average writers, there were no significant differences between the mean scores on the content examinations of the two groups (see Table 4).

There were no significant differences in the means of the problem-solving pretest scores (see Table 3) or the means of the problem-solving posttest scores (see Table 4) of the above average writers and the control group.

TABLE 3

ABOVE AVERAGE WRITERS VS ENTIRE CONTROL GROUP
ACT MATHEMATICS SCORES AND PROBLEM-SOLVING PRETEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			ABOVE AVERAGE WRITERS			
	n	M	SD	n	M	SD	t
ACT	31	16.65	5.12	6	17.33	7.97	0.27
Pretest	31	7.55	2.58	6	8.83	3.31	1.07

Not significant at $p < .05$

TABLE 4

ABOVE AVERAGE WRITERS VS ENTIRE CONTROL GROUP
CONTENT EXAM SCORES AND PROBLEM-SOLVING POSTTEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			ABOVE AVERAGE WRITERS			
	n	M	SD	n	M	SD	t
Exam I	31	79.52	11.14	6	88.50	6.06	1.91
Exam II	31	84.32	13.87	6	86.33	14.04	0.32
Exam III	31	83.26	13.51	6	88.17	9.06	0.85
Posttest	31	9.55	1.82	6	9.33	1.75	0.27

Not significant at $p < .05$

Below Average Writers vs Entire Control Group

The results of independent means t-tests indicate there were no significant differences between the mean scores of the below average writers and the control group on the

mathematics ACT and the problem-solving pretest (see Table 5). There were no significant differences between the mean scores of the two groups on the content examinations and the problem-solving posttests (see Table 6).

It is interesting to note that the mean scores on the content examinations of the below average writers improved consistently. Furthermore, the below average writers showed more improvement in problem solving ability than did the control group as measured by the problem-solving posttest. Not only did the mean scores show more improvement, the individual score on the problem-solving posttest of every below average writer showed improvement over the problem-solving pretest. This was not true of the control group where 26% showed no improvement at all, nor was it true of the above average writers where 50% of the scores went down and only 50% improved.

TABLE 5

BELOW AVERAGE WRITERS VS ENTIRE CONTROL GROUP
ACT MATHEMATICS SCORES AND PROBLEM-SOLVING PRETEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			BELOW AVERAGE WRITERS			
	n	M	SD	n	M	SD	t
ACT	31	16.65	5.12	5	14.20	7.89	0.92
Pretest	31	7.55	2.58	5	6.20	1.10	1.14

Not significant at $p < .05$

TABLE 6

BELOW AVERAGE WRITERS VS ENTIRE CONTROL GROUP CONTENT EXAM SCORES AND PROBLEM-SOLVING POSTTEST SCORES: INDEPENDENT MEANS T-TEST

	CONTROL GROUP			BELOW AVERAGE WRITERS			
	n	M	SD	n	M	SD	t
Exam I	31	79.52	11.14	5	74.00	7.14	1.07
Exam II	31	84.32	13.87	5	79.60	14.59	0.70
Exam III	31	83.26	13.51	5	84.00	13.38	0.11
Posttest	31	9.55	1.82	5	10.20	1.10	0.77

Not significant at $p < .05$

Long Term Study

Independent means t-tests were performed on the mean scores of the ACT and the mean scores of the problem-solving pretest to determine if there were any initial differences in mathematical knowledge and problem solving ability between the two groups in each area of comparison. Because there were no significant differences between the means, the means of the examination scores and problem-solving posttest scores were compared using an independent means t-test.

Because only one below average writer and three above average writers continued in the study for the second term, there is no information given for the below average writers

vs the control group or for the above average writers vs the control group.

Experimental Group vs Control Group

Table 7 shows that the independent means t-tests performed on the means of the ACT scores and the means of the problem-solving pretest scores indicate that there are no significant initial differences in mathematical knowledge and problem-solving ability between the control group and the experimental group. Table 8 shows that although the experimental group had higher mean scores on every content examination except the second, there are no significant differences. Also the experimental group had higher mean scores on both posttests, but they were not significant differences.

TABLE 7

EXPERIMENTAL GROUP VS CONTROL GROUP
MATHEMATICS ACT SCORES AND PROBLEM-SOLVING PRETEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			EXPERIMENTAL GROUP			
	n	M	SD	n	M	SD	t
ACT	9	16.00	3.39	13	14.23	6.59	0.7374
Pretest	9	8.89	2.85	13	8.00	2.42	0.7651

Not significant at $p < .05$

TABLE 8

EXPERIMENTAL GROUP VS CONTROL GROUP
CONTENT EXAM SCORES AND PROBLEM-SOLVING POSTTEST SCORES:
INDEPENDENT MEANS T-TEST

	CONTROL GROUP			EXPERIMENTAL GROUP			
	n	M	SD	n	M	SD	t
Exam I	9	82.00	10.23	13	86.62	8.42	1.16
Exam II	9	91.44	9.96	13	85.77	15.21	0.98
Exam III	9	83.78	12.42	13	91.08	8.52	1.64
Exam IV	9	77.89	16.69	13	80.38	8.03	0.47
Exam V	9	78.89	20.91	13	86.38	10.96	1.10
Exam VI	9	74.44	13.85	13	81.38	10.85	1.32
Posttest I	9	8.89	1.69	13	10.08	1.38	1.75
Posttest II	9	5.00	3.67	13	5.77	2.80	0.56

Not significant at $p < .05$

Reactions of Students Toward Journal Writing

The writing task assigned for the last journal assignment each quarter was "Please give your reaction to writing a journal for a mathematics class." Twenty-six (81%) of the students responded with positive comments. One (3%) was neutral, and five (16%) were negative.

Five of the six above average writers said that they "enjoyed" writing in a journal. The other said it was "helpful." The above average writers spoke more often of

using writing to help them to understand mathematics. "The journal showed me how I approach problems in order to solve them." "Writing helped me to understand . . . better." Three of the five below average writers said they enjoyed it. One said it was "helpful" even though he did not enjoy it and one did not like it at all and did not find it helpful. The below average writers stressed that the journal was a place to ask questions of the teacher.

Average writers reported using the journals in various ways. Some found it useful to gain understanding. One student wrote, "By working through and asking questions about what you're doing, finally you start to understand." Another said, "I feel I have developed more in my understanding of math through journal writing." Some found journal writing useful for asking questions: "We usually don't have time in class for all of the questions that some of us have and the journal is a good way to get these answered." Some students found journal writing useful for several purposes. As one student put it, "If I <u>really</u> didn't understand--sometimes I did by the time I had explained the problem to myself on paper. And if that didn't work, I could always ask you!"

Three average writers with above average ACT scores gave writing-to-learn a negative evaluation. Another negative evaluation came from a below average writer with a low ACT score. Only one negative evaluation came from an

average writer with an average ACT score. This suggests that if writing is to be effective as a learning tool, the student must be able to write well and/or the material must be challenging. Otherwise the assignments may be boring and more "time consuming" than helpful.

The study was conducted during the second and third quarters of a three quarter sequence of mathematics for preservice elementary teachers. It is interesting to note that the average and below average students who gave journal writing a negative evaluation received their best grades of the three quarter sequence while writing in a journal.

None of the students with negative evaluations turned in the journals complete and on time consistently. One student had late or incomplete entries six of the seven times that they were collected and then said, "I don't think that writing in a journal has helped my performance in math."

Fourteen students compared journal writing with quizzes. Four said that they preferred quizzes because quizzes forced them to study each section more and keep up with the homework. The other ten preferred to write in a journal because they could be more relaxed as they wrote detailed explanations that helped them to better understand the problems.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This experimental study examined the effects of journal writing as a means of learning mathematical concepts and improving the problem solving skills of students enrolled in a mathematics class for preservice elementary teachers at the University of Tennessee, Knoxville.

The study was done in two parts. The first was a short term study of one quarter duration. In this study the mean scores of the content examinations, a problem-solving pretest and a problem-solving posttest were compared in three ways. The entire experimental group was compared to the entire control group. The above average writers of the experimental group were compared with the entire control group, and the below average writers of the experimental group were compared with the entire control group.

The second part of the study examined the work of those students who remained in the same treatment groups for a second quarter. Because so few above average writers and below average writers continued in the same treatment groups, some comparisons were deleted from this long term study and only the data of those remaining in the entire

experimental group and the entire control group were examined.

The students in the experimental class were given eighteen open-ended journal writing assignments each quarter that included mathematical concepts, attitudes, goal setting, and reflection upon previous work. They were also encouraged to ask questions or make other comments at any time. Journals were collected seven times during the quarter and feedback was provided by the teacher.

The students in the control class were given a quiz over the homework every Friday. The same lectures were presented to both groups and both groups were given the same homework.

Effects of Journal Writing On Mathematical Content Examinations

In the short term study, the mean scores of the content examinations of the control group were compared with the mean scores of the content examinations of the entire experimental group, the above average writers of the experimental group, and the below average writers of the experimental group. The entire experimental group and the above average writers of the experimental group had mean scores on the content examinations that were higher than the mean scores of the control group on the content examinations in every instance, but they were significantly higher,

$p < .05$, on only one examination. The below average writers had a higher mean score on only the last examination, but they seemed to be improving with each subsequent examination.

Results for the long term study were about the same. The experimental group had higher mean scores on every mathematical content examination but the second one, but the difference was never significant at the $p < .05$ level. In terms of the overall study, it can be said that journal writing was as effective as weekly quizzes in preparing preservice elementary teachers for mathematics content examinations.

Effects of Journal Writing On Problem Solving Performances

The problem solving posttests did not show any significant differences, $p < .05$, between the mean scores of any of the comparison groups in problem-solving ability. One reason for this lack of improvement could be that most of the students had never used writing in a mathematics class before and it may take time to become comfortable with writing about mathematical concepts.

Student Reactions to Journal Writing Assignments

Eighty-six percent of the students in the experimental class gave writing-to-learn in a mathematics class a positive evaluation. In response to the journal assignment,

"Please give your reaction to writing a journal for a mathematics class," many said that they enjoyed writing in the journals and found it to be helpful. Most said that writing helped them to understand the content, helped to relieve anxiety and frustration, and improved their relationship with the instructor. Writing in a journal gave the students an opportunity to ask questions of the instructor that they did not want to ask in class.

Of the fourteen students who compared journal writing with taking quizzes, ten said that they preferred journal writing because it was not as stressful as quizzes. Some students said that they blanked out or became very nervous on quizzes but that they could do the journal writing at home in a relaxed atmosphere. This suggests that journal writing can cut down on anxiety and promote more positive attitudes toward mathematics. Such attitudes may be helpful in preparing better teachers of mathematics at the elementary level.

The students who were rated as above average writers were more likely to consider writing as a way to help them understand concepts and work out problems. The above average writers were also more likely to express their feelings and frustrations than either the average or below average writers. Those rated as below average writers found writing helpful mainly as a way to ask questions of the teacher.

Teacher Reactions to Journal Writing Assignments

The teacher received insight from the journals that was helpful. When students did not understand a concept, that fact became clear to the teacher while reading the journals, so that there was some motivation to discuss the material further. Sometimes clarifications were limited to a note in a single journal; sometimes handouts with detailed explanations were prepared for the whole class. Sometimes the difficult concept was discussed further in class.

The journals helped the teacher to be more aware of the progress of individual students than did the quizzes. As the students wrote out detailed explanations of concepts or problems, misunderstandings became evident. Weekly quizzes that were completed in ten to fifteen minutes rarely provided this insight into the students' level of understanding.

The students were not shy about giving opinions on how the class had gone . . . especially when it did not go well. They let it be known when they did not understand the concepts or could not see how the material would be useful to them. This made it clear to the teacher that it was necessary to be very thorough when showing the relationships between concepts. The teacher felt that the feedback from the students helped her to grow as a teacher and to improve instruction.

Journals helped the teacher to know the students better as total persons and not just as mathematics students. They often discussed their personal problems as well as mathematics. The student-teacher interactions became more personal.

Implications for Teaching

Three students who had above average mathematical knowledge as measured by the ACT but had average writing ability said that they did not find the journals to be helpful and worthwhile but felt that the writing was tiresome and time consuming. The content of the class was relatively easy for them; much of it was review. It seems that these students did not benefit from the writing assignments because they already knew and understood the material. To be effective, the assignments must be challenging and tailored to the needs of the individual students.

The National Council of Teachers of Mathematics (1989) recommends the use of writing to learn mathematics in the elementary school. If it is true that teachers will teach as they are taught, then writing should be used in the mathematics classes for preservice elementary teachers so that they will have experienced writing-tolearn. Mathematics teachers have been found to give up on writing, even when they understand the theory behind it, because they are not

sure about how to apply it in their classes (Fulwiler, 1984). But if the teachers have actually used writing for an extended period of time and have developed positive attitudes toward writing, they are more likely to use it successfully in their own classrooms.

Suggestions for Further Research

The responses to the open-ended question about the reactions of the students raised many questions. It would be interesting to provide a questionnaire with specific questions about student reactions to keeping a journal.

A similar study could assess the affective characteristics of students in the study. Most of the students enjoyed the writing activities. It is possible that writing would help to improve attitudes toward mathematics and to lessen anxiety.

The effectiveness of journal writing for students of different writing abilities could be shown more clearly if the students in the control class had also been grouped by writing ability. Writing samples could be collected from the control class at the beginning of the study so that the above average writers in the control class could be compared with the above average writers in the experimental class, and the below average writers in the control class could be compared with the below average writers in the experimental class.

Journal writing could be used with other student populations to help determine if writing is more or less successful in other subject areas or with other age groups. Other groups might include students taking more advanced mathematics classes, students in a community college, high school students, or elementary students. The subjects in this study were almost all women. Other studies could be designed to include a better balance between males and females.

Similar studies could be done in other areas of the educational program of preservice elementary teachers. The use of journal writing could be studied in other content areas such as science and social studies as well as in professional education courses such as methods courses or field experience.

The journals in this study were collected weekly. Given the demands this makes upon the instructor's time, it would be of value to know if the journal would be as effective if they were monitored less closely. Perhaps a study could be done in which the journals are collected only two or three times during the term.

Several students said that they planned to use journal writing with their elementary classes when they become teachers. A follow-up study might show how many actually did use writing. These teachers could be compared to other teachers who were using writing-to-learn in their

mathematics classes, but had never been exposed to it as a student, to see if there is a difference in the attitudes of the teachers in the two groups toward writing and ease of implementation.

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APPENDICES

APPENDIX A

Your section of Mathematics 2130 has been selected for participation in a pilot study. The purpose of this study is to determine the effect of keeping a journal on the test scores and the problem solving skills of students taking Mathematics 2130 at the University of Tennessee-Knoxville. The study will be conducted during the spring quarter, 1988 and will last for ten weeks. In addition to the three examinations that are given as part of the course, you will be given two tests of problem solving, one during the first week of the quarter, and one at the end of the quarter. Your high school grade point average and mathematics ACT score will be used for statistical analysis.

Your identity will be kept confidential. Only the investigator and the faculty advisor will have access to your test scores, high school grade point average, and mathematics ACT score. Only aggregate results will be reported, and your individual test sheets will be destroyed as soon as the results are statistically compiled. Any reference to individual performance will be disguised to protect your identity.

Your participation in this study will help determine whether journal writing is effective in improving problem solving skills. You are free to refuse to participate in this study and may end participation at any time without penalty.

If you have questions about the research, either now or later, please contact Joan Henn, 333 Ayres Hall, University of Tennessee, Knoxville, 974-2461

****

I have read and understand the explanation of this study and agree to participate.

_____ _____

Name Date

_____

Signature

_____ _____

Signature of parent or guardian (If under eighteen years of age) Date

APPENDIX B

JOURNALS

Journals exist somewhere on a continuum between diaries and class records. Diaries are records of personal thought and experience. Class notebooks are records of other people's facts and ideas. Like the diary, the journal is written in the first person. Like the class notebook, the journal focuses on academic subjects.

The focus of the journal may be narrow or it may be broad. It may include only math concepts or it may include a wide range of experience.

Each journal entry is to be a deliberate exercise in expansion. "How accurately can I describe or explain this idea? How far can I take it?" The journal should help you expand your awareness of what is happening, personally and academically to you.

Experiment with your journal. Write often. Take some risks with form, style and voice. You might see if your writing is different in the morning than it is at night. You might see what kinds of results you get if you write at the same time each day, regardless of your mood.

A journal is a place to fail, to experiment, to try. Judgment, criticism, and evaluation are suspended. What matters is the attempt, not the success of the attempt.

Pay attention to writing as a process and don't worry about product perfection - grammar, spelling, punctuation, form, and style. This is your own voice.

Try "free writing." Free associate while you write as fast as you can. You don't have to think hard or prepare or be in the mood. Without stopping, just write whatever words come out.

When you're blocked, do process writing. Think, "Why am I stalled? Why do I have writer's block?"

Use your journal to ask questions or to make comments. If something is not clear, let me know. I will try to provide an answer.

How long should a journal entry be? That depends on how much you have to say. Write until you are finished, then quit.

Fulwiler, T. (1980). Journals across the disciplines. English Journal, 69(9), 14-19.

APPENDIX C

FOCUSED HOLISTIC SCORING POINT SCALE
From HOW TO EVALUATE PROGRESS IN PROBLEM SOLVING
By Charles, Lester and O'Daffer

0 Points
These papers have one of the following characteristics:

1. They are blank.
2. The data in the problem may be simply recopied, but nothing is done with the data or there is work but no apparent understanding of the problem.
3. There is an incorrect answer and no other work is shown.

1 Point
These papers have one of the following characteristics:

1. There is a start toward finding the solution beyond just copying data that reflects some understanding, but the approach used would not have led to a correct solution.
2. An inappropriate strategy is started but not carried out, and there is no evidence that the student turned to another strategy. It appears that the student tried one approach that did not work and then gave up.
3. The student tried to reach a subgoal but never did.

2 Points
These papers have one of the following characteristics:

1. The student used an inappropriate strategy and got an incorrect answer, but the work showed some understanding of the problem.
2. An appropriated strategy was used but--
   a) it was not carried out far enough to reach a solution (e.g., there were only 2 entries in an organized list);
   b) it was implemented incorrectly and thus led to no answer or an incorrect answer.
3. The student successfully reached a subgoal, but went no further.
4. The correct answer is shown, but--
   a) the work is not understandable;
   b) no work is shown.

3 Points
These papers have one of the following characteristics:

1. The student has implemented a solution strategy that could have led to the correct solution, but he or she misunderstood part of the problem or ignored a condition in the problem.
2. Appropriate solution strategies were properly applied, but--
   a) the student answered the problem incorrectly for no apparent reason;

b) the correct numerical part of the answer was given and the answer was not labeled or was labeled incorrectly;
c) no answer is given.

3. The correct answer is given, and there is some evidence that appropriate solution strategies were selected. However, the implementation of the strategies is not completely clear.

4 Points

These papers have one of the following characteristics:

1. The student made an error in carrying out an appropriate solution strategy. However, this error does not reflect misunderstanding of either the problem or how to implement the strategy, but rather it seems to be a copying or computational error.
2. Appropriate strategies were selected and implemented. The correct answer was given in terms of the data in the problem.

APPENDIX D

Math 2120 JOURNAL ASSIGNMENT 1

Write about who you are and why you are taking math 2120. What do you want to get out of this class? Before you can answer this question, you need to know where you are now. The person who rated math a -100 on a scale from one to ten, with the comment, "I'd rather be hit by a K-Trans bus," is in a very place and has different needs than the person who rated math a 9 and said that math is her favorite subject. Think about where you are now and what your goals are. What do you need to do to meet your goals? What are your expectations of the instructor?

Math 2120 JOURNAL ASSIGNMENT 2

It is the first day of a workshop in mathematics for elementary school teachers, and there are 20 people present in the room. To become acquainted with one another, each person shakes hands just once with everyone else. How many handshakes take place?

Use the following questions to help you look back and describe your thinking as you worked toward a solution to the problem.

1. What did you do when you first saw the problem? What were your thoughts?
2. Did you use any problem-solving strategies? Which ones? How did they work out? How did you happen to find a solution?
3. Did you try an approach that didn't work and have to stop and try another approach? How did you feel about this?
4. Did you find a solution to the problem? How did you feel about this?
5. Did you check your answer in any way? Did you feel sure it was correct?
6. How did you feel, in general, about this problemsolving experience?

MATH 2120 JOURNAL ASSIGNMENT 3

Do a double entry journal entry. On one page, discuss the concept of prime numbers (Don't forget the Sieve of Eratosthenes). On the facing page, record comments, questions and personal reactions.

MATH 2120 JOURNAL ASSIGNMENT 4

As you do the homework from section 5-3, keep your journal beside you and write down questions and comments as they occur to you.

MATH 2120 JOURNAL ASSIGNMENT 5

The use of calculators in the elementary schools has been hotly debated. What are the two sides of this issue? What do you believe?

MATH 2120 JOURNAL ASSIGNMENT 6

Introduce fractions to a fourth grader then help him do problems 2 and 5 on page 240.

MATH 2120 JOURNAL ASSIGNMENT 7

Process writing: Think out problems 11 and 16, page 248-249, on paper, writing a detailed explanation of how you arrived at the solution. If you don't find the answers, write about your trouble with the problems.

MATH 2120 JOURNAL ASSIGNMENT 8

More process writing: Think out problem number 9, page 259, on paper. Write a detailed explanation of how you decided which operation to use and how you solved each problem. If you don't find the answers, write about your trouble with the problems.

MATH 2120 JOURNAL ASSIGNMENT 9

Think about your preparation for the examination. Did you have a plan or a goal in mind? Did your plan change as time progressed? Is there anything you could have done differently that would have helped you?

In preparing for the next examination, what do you plan to do the same? What do you plan to do differently?

MATH 2120 JOURNAL ASSIGNMENT 10

a) Discuss the denseness property.

b) Write a detailed explanation of problem number 10, page 275. If you don't find the answer, write about your trouble with the problem. (The answer is 9 9/14 days.)

MATH 2120 JOURNAL ASSIGNMENT 11

Explain problem 21, page 294, carefully. How might using a calculator to do this problem help a child better understand multiplication and division of decimals?

Problem 24 is one of my favorite problems. After doing it, give your reaction.

MATH 2120 JOURNAL ASSIGNMENT 12

In a group of three or four students, discuss solutions to problem number 10, page 275. Choose the solution that seems best. Why is it better than another solution? If your group doesn't find a solution, discuss your efforts so far. (In this case, the term solution refers to the process used to find the answer and not the answer itself.)

MATH 2120 JOURNAL ASSIGNMENT 13

Write a detailed explanation of problems numbered 5 and 6 on page 305.

MATH 2120 JOURNAL ASSIGNMENT 14

Without going out of your way to find them, record any uses of statistics that you see or hear in the next two days. Include statistics found in newspapers, magazines, on radio or TV, in other classes, in conversations, etc.

Math 2130 JOURNAL ASSIGNMENT 1

Write about who you are and why you are taking math 2130.

Glance ahead at chapters 10, 11, and 12 in the book. In what ways do you think that studying geometry will be helpful to you as an elementary teacher? How much emphasis do you think should be placed upon geometry in the elementary school?

If you can, recall your experiences with geometry as an elementary school student. Do you think it was a positive experience? In what way? What would you, as a teacher, do differently with your students?

MATH 2130 JOURNAL ASSIGNMENT 2

As you do your homework from section 10-1, keep your journal beside you and write down questions and comments as they occur to you.

In your journal show your answer to problem number 16. If you feel comfortable doing so, compare your answers with someone else in the class. Were your answers the same or different? When you compared, did you see the figures in a way that you hadn't noticed before?

Math 2130 JOURNAL ASSIGNMENT 3

3. Assume that a person can carry 4 days' supply of food and water for a trip across the desert that takes 6 days to cross. One person cannot make the trip alone because the food and water would be gone after 4 days. How many persons would have to start out in order for one person to get across and for the others to get back to the starting point?

Use the following questions to help you look back and describe your thinking as you worked toward a solution to the problem.

1. What did you do when you first saw the problem? What were your thoughts?
2. Did you use any problem-solving strategies? Which ones? How did they work out? How did you happen to find a solution?
3. Did you try an approach that didn't work and have to stop and try another approach? How did you feel about this?
4. Did you find a solution to the problem? How did you feel about this?
5. Did you check your answer in any way? Did you feel sure it was correct?
6. How did you feel, in general, about this problemsolving experience?

MATH 2130 JOURNAL ASSIGNMENT 4

What are your goals for math 2130? Do you have intermediate goals as well as long range goals? Are these goals different from the goals you had in 2110 and 2120? What do you plan to do to achieve these goals? How do you think the journal can help you? What do you want the instructor to do to help you reach these goals?

MATH 2130 JOURNAL ASSIGNMENT 5

Using the triangle provided, and figure 10-32 on page 456 of your text, explain to a fourth grader that the sum of the measures of the angles in a triangle is 180 degrees.

MATH 2130 JOURNAL ASSIGNMENT 6

Answer questions 2,4, and 5 from "Questions from the Classroom" on pages 481-482.

MATH 2130 JOURNAL ASSIGNMENT 7

What is your goal for the first examination?
What questions do you have about the content?
How do you plan to find answers to these questions?
Do you experience anxiety during an examination? How do you plan to minimize its effect?

MATH 2130 JOURNAL ASSIGNMENT 8

Assume you are a fourth grade teacher. How would you expect your students to behave if a substitute took your class because you were suddenly called out of town for an family emergency?

MATH 2130 JOURNAL ASSIGNMENT 9

Write in your journal about your experiences with LOGO in the computer lab today. Discuss how it will benefit you as an elementary school teacher.

MATH 2130 JOURNAL ASSIGNMENT 10

Process writing: Think out problems 2,5, and 6, on pages 496-497, on paper, writing a detailed explanation of how you arrived at the solution. If you don't find the answers, write about your trouble with the problems.

MATH 2130 JOURNAL ASSIGNMENT 11

Using process writing, do problems 2,4, and 6 on page 502.

MATH 2130 JOURNAL ASSIGNMENT 12

Using process writing, do problems 2a, 6,7, and 8 on page 510.

MATH 2130 JOURNAL ASSIGNMENT 13

1. Use a compass and straightedge to
   a. circumscribe a circle about a triangle.
   b. inscribe a circle in a triangle.
   (See pages 514-515.)

2. Use paperfolding to
   a. circumscribe a circle about a triangle.
   b. inscribe a circle in a triangle.

Compare the two methods. Which do you prefer? Why?

Using either method, use a right triangle, and an obtuse triangle as well as the acute triangle. What happened?

MATH 2130 JOURNAL ASSIGNMENT 14

Answer questions 1,5, and 9 from "Questions from the Classroom" on pages 556-557.

MATH 2130 JOURNAL ASSIGNMENT 15

Use examples found in everyday life as you explain line symmetry, turn symmetry, and point symmetry to a second grader.

MATH 2130 JOURNAL ASSIGNMENT 16

Examination II is looming on the horizon. As you review the material in chapter 11, write down questions that you have as well as any comments regarding geometry, studying geometry as a student, teaching geometry in the elementary school, or anything else that you feel will be helpful in preparing for the examination.

MATH 2130 JOURNAL ASSIGNMENT 17

The United States is the only developed country which has not embraced the metric system as its official measurement system. Do you believe that Congress ought to pass a law to replace the English system with the metric system? Why or why not?

MATH 2130 JOURNAL ASSIGNMENT 18

Please give your reaction to writing a journal for a math class.

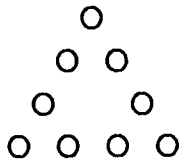
APPENDIX E

Mathematics 2120
Problem Solving Pretest

1. How many ways are there to make change for a quarter using only dimes, nickels and pennies?

2. If I can paint a room in 4 hours and my friend can paint the same room in 2 hours, how long will it take us to paint the room together?

3. Arrange the numbers 1 through 9 in the triangle so that the sums of every side are the same.



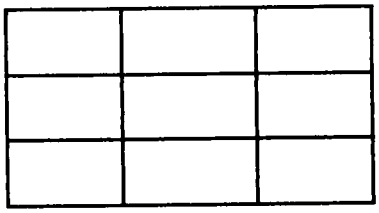
4. It is the first day of class for the course in mathematics for elementary school teachers, and there are 20 people present in the room. To become acquainted with one another, each person shakes hands just once with everyone else. How many handshakes take place?

Mathematics 2120
Problem Solving Posttest

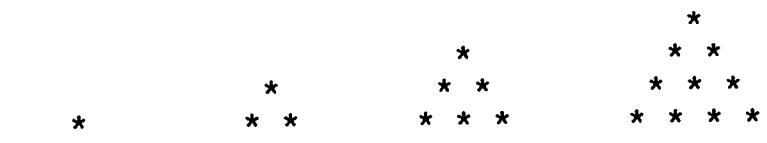
1. Jesse's mother paid him $1.60 allowance in quarters, dimes and nickels. He received 17 coins in all. How many of each coin did his mother give him?

2. A ship goes in one direction, west to Hawaii, at 20 nautical miles per hour and because of the wind, makes the return trip at 30 nautical miles per hour. What is its average speed for the round trip?

3. Arrange the numbers 1 through 9 in the square so that all the rows, columns, and diagonals have the same sum.



4. A number that may be represented by the pattern below is called a triangular number. The first four are shown. What is the one hundredth triangular number?



$t_1 = 1$ $t_2 = 3$ $t_3 = 6$ $t_4 = 10$ ... $t_{100} = ?$

Mathematics 2130
Problem Solving Posttest

1. A ship goes in one direction, west to Hawaii, at 20 nautical miles per hour and because of the wind, makes the return trip at 30 nautical miles per hour. What is its average speed for the round trip? (Hint: The answer is not 25 nautical miles per hour.)

2. A certain make of ball point pen was priced at 50 cents in the store opposite the school but found few buyers. When, however, the store had reduced the price, the whole remaining stock was sold for $31.93. What was the reduced price?

3. In order to encourage his son in the study of algebra, a father promised to pay his son 6 cents for every problem solved correctly and to fine him 5 cents for each incorrect solution. After 26 problems neither owed anything to the other. How many problems did the boy solve correctly?

4. Two pirates were burying their booty on an island, with the Coast Guard in hot pursuit. Near the shore were two large rocks and a lone palm tree. Bluebeard A started from one of the rocks and, walking along the line at right angles to the line joining the rock to the palm tree, paced off a distance equal to that between the rock and the palm tree. Bluebeard B did a similar thing with respect to the other rock and the palm tree. They they walked toward each other and buried the treasure halfway between. Two years later the pirates returned to the island to dig up their treasure but they found that the palm tree was no longer there. How can they find the treasure?

VITA

Joan E. Henn was born in Dayton, Ohio on August 23, 1942. She graduated from Jefferson Township High School in 1960. The following September she entered the University of Dayton and attended for two years. She reentered several years later and in 1972, she received a Bachelor of Science degree in Elementary Education.

After teaching for eleven years in public schools and the Knoxville Job Corps, she entered the University of Tennessee. In 1984 she accepted a graduate teaching assistantship in the mathematics department and continued study toward a Master of Mathematics degree. This degree was awarded in August, 1985.

She continued her study at the University of Tennessee and received the Doctor of Philosophy degree with a major in Mathematics Education in December, 1989.

The author is a member of the National Council of Teachers of Mathematics, the Illinois Council of Teachers of Mathematics, Mathematical Association of America, and Phi Delta Kappa. She is currently an assistant professor of mathematics at Eastern Illinois University, Charleston, Illinois.