5-31-1996

The effects of journal writing on academic achievement in high school Integrated Mathematics I

Jane LaMarra
Rowan College of New Jersey

THE EFFECTS OF JOURNAL WRITING ON ACADEMIC ACHIEVEMENT IN HIGH SCHOOL INTEGRATED MATHEMATICS I

by
Jane LaMarra

A Thesis

Submitted in partial fulfillment of the requirements of the
Master of Arts Degree in the Graduate Division
of Rowan College of New Jersey in Mathematics Education
1996

Approved by _____
Professor

Date Approved May 1996

ABSTRACT

Jane LaMarra, The Effect of Journal Writing on Academic Achievement in High School Integrated Mathematics I, 1996, J. Sooy, Mathematics Education

The purpose of this study was to determine if there was a significant difference in the level of academic achievement in responding to open-ended questions between those students who wrote in journals and those who did not write in journals, in an Integrated Mathematics I class.

The sample consisted of thirty-three students from two *Integrated Mathematics I* classes; there were eighteen students who wrote in journals (the experimental group) and fifteen students who did not write in journals (the control group.) Integrated Mathematics I is a course designed for ninth grade non college-bound students, where emphasis is placed on skills necessary for successful completion of the New Jersey High School Proficiency Test. Achievement tests containing open-ended questions were administered to both groups prior to and following the experiment. An independent t-test was performed to see if there was any significant difference in the level of academic achievement in responding to open-ended questions.

The study indicated that there was no significant difference in academic achievement between those students who wrote in journals and those who did not write in journals.

MINI-ABSTRACT

Jane LaMarra, The Effect of Journal Writing on Academic Achievement in High School Integrated Mathematics I, 1996, J. Sooy, Mathematics Education

The purpose of this study was to determine if there was a significant difference in the level of academic achievement in responding to open-ended questions between those students who wrote in journals and those who did not write in journals, in an Integrated Mathematics I class.

The study indicated that there was no significant difference in academic achievement between those students who wrote in journals and those who did not write in journals.

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

TABLE Page

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. John Sooy for his support and faith in me throughout this past year. To my study group, I extend my appreciation for the many effective discussions and analysis we had - we succeeded, after all, in truly discerning between that which is ***reliable*** and that which is ***valid***.

To my dear sister-in-law, Linda Miller and her daughter Noelle, a heart-felt thanks for entertaining my children (and they loved every minute of it) so that I could devote the indispensable time and concentration into completing this thesis. To my children, Mark and Danielle, you have been ever so patient and understanding throughout this year of mommy living in the computer room - I love you two dearly!

Finally, to my husband Mark, I will look back at this past year forever gratefully - I could never have done it without you! Your emotional support, your relentless patience, your perserverence, and of course your delicious dinners, carried me through a rough year. You are the epitome of a loving and supportive husband and father - I love you!

CHAPTER I

Introduction to the Study

Introduction

Open-ended questions comprise 45% to 55% of the High School Proficiency Test, a test that New Jersey public school students must pass in order to graduate from high school. The question that arises is: how do we better prepare low ability students for responding to open-ended questions - problems that not only necessitate the knowledge of mathematical computations and manipulations, but also the ability to communicate that knowledge comprehensively. Having studied some of the results of past H.S.P.T. tests, the researcher has found that a majority of the failures were a direct result of the inability of the students to respond to open-ended questions.

The sixth standard of The New Jersey Mathematics Curriculum Standards (drafted July 13, 1993) suggests that mathematics should be communicated in writing because writing is one of several techniques that leads to a better understanding of mathematics and its use.

Studies on students' difficulties with writing in mathematics class indicates that simply giving students the opportunity to write or asking them to write, does not produce better communicators. Researchers have found that students need guidance and direction in order to become better writers or thinkers (Graves 1983; Caulkin 1986).

Using journals on a regular, routine basis whereby students respond to teacher generated open-ended questions addresses several needs in the learning process: (1) students have guidance in their writing; (2) teachers will gain a better understanding of students' thinking (Norwood and Carter 148); (3)

students practice responding to open-ended questions in a non-threatening medium; "Journal writing is a private, enlightening procedure. Turning off one's internal sensor can allow latent ideas to surface (Burton 42);" (4) students can "release their anxieties about mathematics and the problems they encounter in the learning process (qtd. in Miller 517)."

Statement of the Problem

The purpose of this study is to determine if there is a significant difference on the level of achievement in responding to open-ended questions between those students who write in journals and those who do not write in journals, in an Integrated Mathematics class .

The null hypothesis to be tested is:

H_0: there is no significant difference in the level of academic achievement between the students who write in journals and those who do not.

Significance of the Problem

The National Council of Teachers of Mathematics, *Curriculum and Evaluation Standards for School Mathematics* (1989) calls for teaching students to communicate mathematically. The High School Proficiency Test (H.S.P.T), a test taken by New Jersey eleventh grade students as a part of their graduation requirement, contains from 45% to 55% open-ended questions (New Jersey State Department of Education). This implies that a student could obtain a perfect score on the multiple choice section and still fail this test if he/she neglects to respond to the open-ended questions. It is the intention of the researcher to utilize journal writing in the classroom as a means of having students communicate mathematically, a skill necessary for successful response to open-ended questions.

"Open-ended problems engage students in interesting situations and allow students at many levels of understanding to begin working on the problems, make their own assumptions, develop creative responses, and effectively; communicate their solutions" (Pandey, 1991). The journal provides a medium for students to respond to problems initiated by the teacher, openly, without the stipulation of a grade. Open-ended questions require a student to think from different angles and to be creative in responses. Journal writing provides a means of brainstorming out loud, where building on expressed ideas is encouraged (Burton, 41).

Through journal writing the researcher aspired to examine the process thinking that occurs when students respond to open-ended questions - problems that require no right or wrong responses, but full explanations to justify their means to the solution.

It is the intention of this study to determine if students achieve in responding to open-ended questions - a major component in the test for fulfilling graduation requirements - by communicating mathematical ideas routinely in a journal.

Limitations

This study was conducted at Gateway Regional High School, a school system comprised of students in grades seven through twelve, with an approximately 4% minority population.

Two classes in Integrated Mathematics I were used for the experiment. Integrated Mathematics I is a course for ninth and tenth grade non college-bound students, where emphasis is placed on skills necessary for successful completion of the High School Proficiency Test. One class (experimental group)

has eighteen students and meets every day at 11:45 a.m. The other class (control group) has fifteen students and meets the last period of the day at 1:25 p.m. There are seven mainstreamed special education students in the two classes. The percentage of mainstreamed students in the classes that were studied is comparable to the percentage of mainstreamed students normally placed in the Integrated Mathematics I classes.

It is assumed in the study that all students in the experimental group are keeping a journal, and that academic achievement means a passing grade of 65.

Definitions of Terms

Ability. The capacity to do something; the powers to perform, which are influenced through educational experiences as well as by natural talents, aptitudes or trails (NCTM 87).

Academic Achievement. Measure of the knowledge attained or the skills developed in a school subject by a student in a particular marking period (Good and Merkel 7). In the researcher's Integrated Mathematics I class, it is based on 65% passing on an open-ended test.

Control Group. The one of two or more experimental groups that is not subjected to the experimental factor or condition introduced into the treatment of the experimental group (Good 24). In the researcher's classes, the control group is the Integrated Mathematics I class of fifteen students, period seven, not using a journal.

Experimental Group. The one of two or more groups that is subjected to the experimental factor or condition, the effect of which it is the purpose of the experiment to discover (Good 32). In the researcher's classes, the experimental

group is the Integrated Mathematics I class of eighteen students, period five, using a journal.

H.S.P.T. The High School Proficiency Test, the test all eligible New Jersey high school students must pass in order to graduate from high school.

Journal. Keeping of a personal notebook, where students can write down any thought related to their mathematics learning (Borasi 356), and where students can openly respond to teacher initiated problems.

Measure. To indicate how much of some specified quantifiable unit is present; to assign numbers to variations in a quantifiable attribute or trait (NCTM 89).

Open-ended questions. Tasks that allow for various acceptable answers and for multiple approaches to an effective solution (NCTM 89).

Rubric. A set of authoritative rules to give direction to the scoring of assessment tasks or activities (NCTM 90).

Skills. Abilities to perform routine mathematical procedures, typically by computational or manipulatory method (NCTM 90).

Standard. A statement about what is valued that can be used for making a judgment of quality (NCTM 90).

Task. An authoritatively specified or assigned, purposeful, contextualized activity (NCTM 90).

Procedures

The population used for this study was comprised of students from two Integrated Mathematics I classes at Gateway Regional High School, Woodbury Heights, New Jersey. The students in these classes are non college-bound students, who are in need of extra preparation for the High School Proficiency

Test.

Both classes were taught by the researcher, utilizing the same method of instruction with one exception - the experimental group wrote in journals three to four days a week, and the control group did not write in journals. The ability level in both groups was comparable as determined by an open-ended question test given to both groups prior to the experiment. One group (control group) had two special education students out of fifteen students and the other group (experimental group) had five special education students out of eighteen students.

This study commenced at the beginning of the third marking period in February, 1996, and terminated at the end of the same marking period, April, 1996, encompassing a period of eight weeks.

The students in the experimental group were required to write in a journal two to three days a week. The researcher initiated an open-ended problem and the students were to write their responses in the journals. Along with these responses, the students were encouraged to express any frustration or confusion they encountered. Journals were collected every Friday, at which time the researcher wrote comments or suggestions to the students. Journals were returned to the students the following Monday.

Both the control and the experimental groups were administered a cumulative test at the end of the study to compare academic achievement. An independent t-test was performed to compare the results of the two exams.

WORKS CITED

Borasi, R. and B.J. Rose. "Journal Writing and Mathematics Instruction." Educational Studies in Mathematics 20 (1989): 347-65.

Burton, Grace M. "Writing as a Way of Knowing in a Mathematics Education Class." Arithmetic Teacher 33 (December 1985): 40-45.

Calkins, Lucy. The Art of Teaching Writing. Portsmouth, NH: Heinemann Books, 1986.

Good, Carter V. Dictionary of Education. New York: McGraw-Hill Book Company, Inc., 1959.

Good, Carter V. and Winifred Merkel. Dictionary of Education. 3rd ed. New York: McGraw -Hill Book Company, Inc., 1973.

Graves, Donald H. Writing: Teachers and Children at Work. Exeter, NH: Heinemann Educational Books, 1983.

Miller, L. Diane. "Writing to Learn Mathematics." Mathematics Teacher. (October 1991): 516-521.

National Council of Teachers of Mathematics. Assessment Standards for School Mathematics. n.d.

National Council of Teachers of Mathematics. Curriculum and Evaluation Standards for School Mathematics. Reston,VA: NCTM, 1989.

Norwood, Karen S. and Glenda Carter. "Journal Writing: An Insight Into Students' Understanding." Teaching Children Mathematics. 146-148.

Pandey, Tej. A Sampler of Mathematics Assessment. California Assessment Program. Sacramento, CA: California Department of Education, 1991.

CHAPTER II

Review of Related Literature and Research

Introduction

The Curriculum and Evaluation Standards for School Mathematics (Standards) (NCTM 1989) identifies learning to communicate mathematically as one of its primary goals. One of the mediums through which to communicate mathematically, is the process of writing, a technique that has been explored in mathematics classrooms at all levels - from elementary to post-secondary schools. It has been researched that journal writing in particular increases understanding of mathematics (Stewart and Chance 92), and provides an excellent diagnostic tool for teachers (Borasi and Rose 349).

In each of the following two sections, the researcher reviews writing from the elementary to post-secondary levels, then journal writing from the elementary to the post-secondary levels as it relates to literature and research.

Review of Related Literature

.According to Margaret McIntosh in her article entitled, "No Time For Writing In Your Class?", mathematics teachers would be more apt to include writing in their classes if they did not view writing as a topic to teach, but rather as a teaching technique (423).

McIntosh recommended incorporating writing activities such as learning logs, journals, expository writing, and creative writing (423). By doing so, all students become actively involved in the learning, communication lines between teacher and student are opened, students are encouraged to analyze concepts rather than just reiterating them, learning becomes defined in more "human terms," and mathematics begins to have more meaning for the students

(430-33). Finally, Schmidt (1985,116) summarized his reasons for having students write in mathematics classes:

> Writing in math class is not a panacea. Still, by learning and writing about related topics, by writing about problems which puzzle them, by writing about their fears and feelings, students begin to see math in more human terms. For me it is a way to get to know more about those varied and wonderful people who are my students (qtd in McIntosh 432).

In implementing the NCTM standard of communicating mathematically, Nancy Nesbitt Vacc outlined some possible obstacles. For example, some students had trouble verbalizing, some were reluctant to speak out in class, some topics produced argumentative discussions, some students failed to listen to others, and finally, teachers were not always willing to give up control of the conversations (339). Nesbitt did offer solutions to these barriers, such as providing a relaxed atmosphere for the students, asking personal questions to increase student involvement, and helping students through argumentative encounters rather than stopping a discussion (340). However, Nesbitt found that by allowing students time to write down their ideas prior to verbalizing them, did improve the quality of the discussions (341).

According to Judith Mumme and Nancy Shepherd in their article entitled "Communications in Mathematics," communication in mathematics had several educational advantages, one of which was that the process of writing gave students control over their thinking (19). The authors emphasized that the nature of the writing assignments should be more open-ended rather than a recitation of a previously memorized formula, since the former resulted in the students utilizing their own ideas and their own methodologies for thinking (19). In addition, Mumme and Shepherd viewed writing as a means for teachers to delve into the minds of their students, for in writing, teachers were able to

examine the "conceptions and misconceptions" of their students (20).

With cooperative learning becoming a vital element in the mathematics classroom, Alice Artzt in her article entitled, "Integrating Writing and Cooperative Learning in the Mathematics Class," discovered that writing in conjunction with cooperative learning compliment each other (80). When students were not only asked to write about a mathematical topic, but were also asked to share their writing with their cooperative learning group, writing became more comprehensible (81). Artzt found that students were constantly checking for understanding with their peers, students who were relatively in the same mindset and were seeing errors that they themselves may have encountered. In addition, Artzt had students correct their tests in their groups, by discussing and writing the reason for the wrong answers, and then rewriting and justifying the process to obtain the correct answers (82). As a result, the process of writing and working cooperatively led to better preparation for tests, since students were about to review concepts with each other and were more apprised of their errors (Artzt 85).

To further justify the researcher's need to using writing as a means of improving problem solving (open-ended questions), Margaret I. Ford found that writing allowed students to relate to the problems as long as they were guided through the process (35). Her ideas were borrowed from the language arts, using the concept that "writing is a process," consisting of prewriting, writing, conferencing, revising and editing, publishing (35-36). As opposed to journal writing, the type of writing alluded to by Ford was apropos for the elementary level and not on the middle or secondary levels (36).

When confronted with a low ability seventh grade mathematics class,

Nancy Brown noted how writing improved both academic achievement and self-esteem in her article "Writing Mathematics" (20). Students were required to make up their own word problems, which were discussed, edited, and placed in a bound book for use by the entire department (21). One important lesson learned by the teacher was that the students' knowledge of mathematics came out in the writing assignment but was previously not realized by the teacher (20).

In a middle school in Texas, a committee comprised of language arts and mathematics teachers compiled a list of writing topics for use in the mathematics classroom including narrative, descriptive, and expository writing (Haggerty 245). As a general guideline, the teachers agreed that writing should be a daily activity, that teachers should respond to student writing and finally, that teachers should show appreciation of student writing by displaying it, including positive comments or provide stickers on papers (246).

As an experiment to improve communication skills among low ability students, Lynn Havens, a teacher and codirector of a National Diffusion Network content reading program, incorporated writing in her high school general mathematics class (551). Initially, writing was ineffective when students had neither a specific format to follow nor a criteria for expectations (551). Once a detailed checklist was given to the students, writing gradually improved (552). It was discovered that students needed a specific writing topic, a specific format (such as summary, journal entry, letter, etc.), a designated length, and one rule of sentence structure in grammar, in order to have success in the assignment. As an added enhancement, the teacher had students write to a non-mathematical person (such as a fifth grade student) in order to force detail in the

writing (551).

Although Havens initially met with obstinateness among her students, her experiment led to a better understanding of the mathematical process and the ability to communicate mathematical concepts to others (554).

Writing has been a rarity in the secondary mathematics level. According to Marvin L. Johnson, it was writing that forces students to think through problems and escape the mechanics of mathematics (117). For example, if a student had to explain a problem with which he/she had difficulty, the student had to organize the concept in his/her mind, thereby developing critical thinking skills that may not have come about, had the problem been explained by the teacher (Johnson 118-19).

In her article entitled, "Writing as a Way of Knowing in a Mathematics Education Class," Grace M. Burton commenced with an apropos quotation:

> We do not think and then write, at least not without putting an unnecessary handicap on ourselves. We find out what we think when we write, and in the process put thinking to work - and increase its possibilities (qtd in Burton 40).
>
> Frank Smith (1982)

In her mathematics education course, Burton used several methods of writing in order to increase comprehension - free-writing, journal writing, and term papers (40). Free writing allowed students to give an immediate reaction to a reading, lecture or film (40). What resulted was that there was a more likelihood of an effective oral discussion or more in-depth paper if the student had the time to express his/her concerns or problems immediately (40).

Along the same lines as free writing is journal writing, whereby

students have the opportunity to brainstorm their thoughts and ideas, according to Burton's article (40). Journals provided the teacher with a means of recognizing individual thought patterns. Instead of only seeing wrong answers in tests, through journals, teachers were able to analyze the *why* of student errors and as a result, were more capable of assisting him/her with the concept (41). Burton pointed out that students are more apt to become accustomed to journal writing if it was a routine procedure, if it was collected on a regular basis, and if the teacher included his/her responses in the journal (Burton 41-2).

A more specific genre of writing that the researcher focuses on in the following paragraphs is that of journal writing. Minja Paik, a mathematics professor at George Marson University, has documented that students who keep journals score 15 percent higher on tests than students who do not keep journals (Thaiss 1982). In addition, Watson (1980) found that students showed improvement in problem solving when utilizing journals on a routine basis (qtd. in Mett 534).

Commencing on the elementary level, a group of elementary educators, as a part of a grant to work on restructuring elementary mathematics, utilized journals as a means to record any changes or growth that occurred as a result of their work, which led to bringing journal writing into their mathematics classrooms (Atherton et al. 46).

In order to make journal writing effective, Atherton, Joyner, Pender, Ryerson, and Young had a specific routing plan that each of them adhered to in his/her class (Atherton et al. 46). First of all, students had total responsibility for their own journals - it was simulated to be a

personal diary. In addition, students were given guidance or a lead-on question or statement to assist the student in formulating ideas. Their ideas can be in the form of pictures as well in order for the kindergarten students to partake in the activities. Another effective element of journal writing was to allocate plenty of time for the students to write in their journals. Finally, when discussions were conducted relative to the journal writing, students were more apt to participate since after each discussion period more ideas are formulated (Atherton et al. 47).

Another experiment with journal writing on the elementary level was discussed by Sonia M. Helton in her article entitled, "I Thik The Citanre Will Hoder Lase: Journal Keeping in Mathematics Class" (336). Helton used the constructivist principle that "all knowledge is constructed by the learner and therefore, learning is an intensely personal affair" (qtd in Helton 336). Helton believes that a journal allows a child to take a given concept or problem and restate or explain the idea in his/her own words (336).

Journals can have several different uses to different teachers, according to Helton (337). For example, students can use journals to interpret story problems by rewriting the story in their own words, illustrating the problem by pictures or diagrams, and writing a mathematical sentence that will solve the problem (337). Another use of journals is to relate mathematical concepts to real-life problems suggested by the students themselves. Helton did emphasize that once a problem is devised by the students, teachers must in turn direct the students by asking pertinent questions regarding the real-life situation

(338). The final application for journal writing suggested by Helton involved the analysis of the students' thinking (338). With this aspect of journal writing, teachers are able to delve into the minds of the students and are more capable of targeting in on the mathematical difficulties of individual students (338). Helton pointed out that it is imperative that teachers intervene in this type of writing in order to correct an erroneous thought process immediately (338). Finally, Helton recommended that teachers utilize journals along with the students in order to model the writing process and to get them into an appropriate mindset for writing (339).

Journal writing on the elementary level was the center of focus on the article "Have a Problem? Make the Writing-Mathematics Connection!" (Wadlington et al. 207-9).

In their article, Wadlington, Bitner, Partridge, and Austin followed a structured program for incorporating journal writing (207). Students commenced by writing daily in their journals about mathematical activities that occurred in the classroom. No regard was given for spelling or punctuation, and the journals were not graded (208). Once students were acclimated to the concept and procedure of journal writing, cooperative learning was used in conjunction with journal writing (208). Set guidelines and rules were first directed to the students, then journals were used to explain the activities performed in their groups, as well as the students' reactions to their cooperative groups. The insight gained by teacher was twofold. He/she discovered the effectiveness of the groups, and students were thinking about the mathematics learned in class

(209). Journals in these classrooms, empowered the students with more in-depth thinking capability, desire to perform problem solving activities, and value for mathematics as it relates to the real world (209).

Several suggestions for incorporating journal writing in a fifth grade class was outlined in an article entitled, "Journal Writing: An Insight Into Students' Understanding" (Norwood and Carter 146). In Norwood's class, journals were used to get students to write ideas on a concept prior to being taught the concept, to write algorithms for given mathematical concepts, and to explain their feelings or ideas on a concept (146). In order to integrate journal writing in the classroom, Norwood suggested the following: commence journal writing at the beginning of the year, have students address journal entries to a friend or relative since they would be more apt to write more, give a time limit for journal writing, the teacher needs to respond every few days to the journals, give the students prompts or question in order to get them thinking, have the students make their own covers for the journals in order to personalize them, and the teacher needs to participate in journal writing along with the students (146-7).

In Norwood's article, she emphasized many positive effects journal writing had on her class. In particular, students became more aware of how mathematics related to other subject areas; it was easier for the teacher to remediate students by viewing their thought processes; students became better thinkers and more effective mathematicians (147).

When discussing journal writing in their article entitled, "Using

Writing to Learn Mathematics," Nahrgang and Petersen alluded to an appropriate quotation by Watson (1980):

> This two-way conversation has become beneficial to the class. The students realized I hear them and care. They seem to have looked inside themselves and to have seen what they could do to help solve their mathematical problems. Many of their grades improved (qtd in Nahrgang and Petersen 461).

Nahrgang and Petersen, through the experience of journal writing from algebra through calculus, viewed journal writing as the most effect means of writing (461). Journal writing provides an informal milieu that is conducive to free thinking, alleviating the fear of a grade for writing style (461). As students became accustomed to journal writing, they became capable of connecting learned knowledge to experienced knowledge (461).

Nahrgang and Petersen discovered that journal writing provided an excellent means of pinpointing students' mathematical errors because teachers were reading the students' thoughts, something that does not appear on a routine test or quiz (463). In addition, these authors found that both teacher responses to journal entries and extra credit or a grade for journals, were essential; it gave the students motivation for turning in quality entries (463). Finally, Nahrgang and Petersen felt that having the capability of viewing the students' progression toward understanding a concept, instructors had an excellent "diagnostic tool" in journal writing (464).

Journal writing was found to be an effective teaching technique on the college level as well, evidenced in Coreen Mett's article entitled,

"Writing in Mathematics" (293-96). Mett found that the effects of writing on learning was hard to measure through some diagnostic test because she feels that journal writing has effects on "long term retention and improved study habits," something hard to measure through statistics (293).

Mett incorporated journal writing in her college level courses, although the techniques she described could be transferred to lower level classes (293). In Mett's classes, students were required to keep journals, which were counted as ten percent of their grade (for completeness only) (294). Students wrote in their journals each class period as well as at home (294). Journals were collected weekly initially, then less often at the end of the semester; with each collection, Mett included comments in the journals (294). Written in the journals were students' description of a given concept in their own words, whereby the teacher immediately detected any misconceptions (293). In addition, students were to relate concepts to the real world, express their confusions, and respond to open-ended questions (294).

Mett emphasized that as mathematics progresses, students are required to think critically about concepts; far deeper thinking is required than in the earlier levels (295). Journal writing provides the means to think about the mathematics, use mathematical language, express the frustrations often associated with mathematics, and relate mathematics to the every day world (296).

In another on of her articles entitled, "Writing as a Learning Device in Calculus," Coreen Mett utilized journal writing in a calculus class at Radford University (534). What she found to be the most effective aspect

of journal writing was the fact that students were encouraged to write freely without concerns about grammar or structure. As a result, students were more amenable about writing in the journals and they found that this form of writing led to the formulation of potential questions about a concept, or it simply provided a means for them to summarize a concept and thus provide a clearer picture of the problem presented (535).

Mett's initial motivation for seeing the importance of writing in the classroom, was the fact that, according to a report by Lampe (1982), scientists report that over thirty percent of their time is spent writing (qtd in Mett 534).

Review of Related Research

According to the study conducted by Daniel Pierce and David Davison on the use of writing in the junior high mathematics classroom, more teachers used writing tasks that did not actively involve the student and those that involved reiteration of given material (10).

Pierce and Davison based their study on 31 junior high teachers, which represented 69 percent of the teachers in the area junior high schools (9). Teachers were asked to discuss the type of writing activities they use, the frequency of their use, the amount of classroom time spent on writing, the nature of the writing activities, and the amount of rewriting that was required (9). Writing was classified into five areas, from simply copying information to using writing to discover patterns, explore concepts or make conclusions (10). Most of the teachers (64 percent) used two or less different types of writing (11). Twenty-three percent of the teachers' only writing activity included copying information from the

board (13).

Through hours of teacher interviews, Pearce and Davison discovered that the reasons for the lack of writing other than for mechanical purposes, was the teachers' inability to devise writing activities conducive to providing a deeper mathematical understanding, and that most of the writing that did occur in the class came from activities written in the textbook (14). Pearce and Davison concluded by remarking that the inclusion of writing in the mathematics curriculum is essential if we want better critical and analytical thinkers (14).

Elizabeth and Ronald Bell conducted a study entitled, "Writing and Mathematical Problem Solving: Arguments in Favor of Synthesis," in a high school ninth grade general mathematics class over a four-week period, to see if utilizing expository writing in conjunction with mathematical problem solving, had any significant affects on learning (214).

In Bells' study, one class used expository writing along with problem solving, and the other class did not (214). In the pretest of Bells' study, there was no significant difference between the two groups (214). However, in the posttest, the group utilizing expository writing with problem solving scored significantly higher than the group that did not use writing (215).

As a vital element in this study, Bell and Bell accentuated that in order for teachers to experience the same success with writing as was realized in their study, teachers must incorporate writing as a regular and routine part of their instruction, not just as an isolated activity (215).

Writing must be a well-planned and structured activity (215). In addition, since many students are not accustomed to writing, Bell and Bell emphasized the need for teachers to guide the students along in the writing process (218). Finally, in Bells' study, through expository writing, students were encouraged to think mathematically, thereby increasing comprehension and critical thinking (219).

In Andrew Waywood's paper, "Informal Writing-To-Learn as a Dimension of a Student Profile," Waywood developed a model of journal writing in mathematics at a secondary school for girls (Waywood 321). Waywood analyzed the journals of four tenth grade students of four different levels of ability, to compare entries of students at the same grade level; journals of one student's ninth and eleventh grade were analyzed for change in mathematical sophistication (325). As a background to this study, it should be noted that journals were used every time a new concept was taught (usually four times a week), and students had to adhere to a strict set of guidelines and expectations (323-24). Journals were analyzed in four general areas: (1) ability to summarize a new concept, (2) ability to include sample problems relative to the new concept, (3) ability to formulate questions, (4) ability to apply new concept (323). The area of focus for Waywood's study was, "[do] questions posed by students in journals contribute to a profile of a student's learning in mathematics?" (325). Journals were graded for questioning on an A (highest) to E (lowest) scale (333). Waywood showed statistically through box plots and a rank order correlation (Kendall tau), that his method of grading shows no evidence that it is

"distinguishable from the grading of other tasks" (335).

In his conclusion, Waywood found that questioning techniques in journals did vary between students at the same grade level (339). In addition, as the years progress, students do improve in mathematical knowledge in their journal writing (339). Waywood found that in the latter study, the student who wrote in a journal from grade seven to grade eleven, demonstrated highly developed critical thinking skills, as opposed to the mechanical tasks of copying and summarizing (337).

The utilization of journals in four high school first year algebra classes and its connection to NCTM's "Professional Standards For Teaching Mathematics (1991), was the center of focus of the study performed by Carolyn Stewart and Lucindia Chance (92). Two of the classes wrote in journals and two did not, over an entire school year (92). The teachers in the classes who wrote in journals also participated in journal writing along with the students (92). Journal entries were made three times a week, with guidance from the teacher, journals were collected each of the days, and responses were made to the entries by the teacher and returned the next day (93). The journal writing consisted of three major categories: (1) explaining mathematical concepts in their own words, (2) reacting to the course itself, (3) free-writing, whereby students express their feelings and frustrations about the learning (92).

At the end of the study, the students in both groups were given a standardized achievement test. Independent t-tests on both the pretest and posttest scores indicated that journal writing improved student achievement significantly ($p \geq 0.05$) (93).

In Stewart and Chance's study, it was found that the first six standards of NCTM's "Professional Standards For Teaching Mathematics (1991)" were addressed through journal writing (93-5). In journal writing, students are encouraged to express their ideas, their thinking, their discoveries, all to which the teacher responds (94). In addition, journal writing provides an excellent communication link between student and teacher, as well as improving mathematical communication (95).

In their study of journal writing entitled, "Journal Writing and Mathematics Instruction," Raffaella Borasi and Barbara Rose discussed the benefits of journal writing on the learning process (347). The study was conducted at a small liberal arts college in a college algebra course for first or second year students. Journals were written in three times a week and were collected every other Friday and returned on a Monday, including comments from the teacher (351). Most of the journal writing occurred at home, without prompts from the teacher; however, students were initially given a list of several open-ended topics that were appropriate for their journals (351). At the end of the study, a student survey, containing four open-ended questions about their feelings toward journal writing was given (351).

As a result of the study, Borasi and Rose found several benefits of journal writing. For the students, their attitude toward mathematics improved since they were regularly expressing their frustrations and concerns; their understanding of mathematics was enhanced because the journal forced them to think about the concept and mentally articulate

the learning; by personalizing the learning, students were able to relate mathematical concepts to real life (352). For the teacher, journal writing assisted teachers in the evaluation and support process since they were able to view their students' thinking; teachers were able to make both short-term and long-term adjustments to the curriculum, by examining students' reactions and comments (352). Finally, as a benefit to both students and teachers, journals improved teacher-student rapport by the constant dialogue between teacher and student (352).

Borasi and Rose emphasized that in order for journal writing to become an effective tool as it was in their study, it is imperative that students use journals to react, to reflect, to "think on paper," not to simply summarize or regurgitate material presented in class (364).

WORKS CITED

Artzt, Alice F. "Integrating Writing and Cooperative Learning in the Mathematics Class." Mathematics Teacher 81.2 (February 1992): 80-85.

Atherton, Christy, et al. "Keeping Math Journals." Instructor 101.8 (April 1992): 46-47.

Bell, Elizabeth and Ronald N. Bell. "Writing and Mathematical Problem Solving: Arguments in Favor of Synthesis." School Science and Mathematics (1985): 210-11.

Borasi, Raffaella and Barbara J. Rose. "Journal Writing and Mathematics Instruction." Educational Studies in Mathematics 20 (1989): 347-65.

Brown, Nancy. "Writing Mathematics." Arithmetic Teacher 41.1 (September 1993): 20-21.

Burton, Grace M. "Writing As a Way of Knowing in a Mathematics Education Class." Arithmetic Teacher 33 (December 1985): 40-45.

Ford, Margaret I. "The Writing Process: A Strategy For Problem Solvers." Arithmetic Teacher 38.3 (November 1990): 35-38.

Haggerty, Donald J. "Writing In the Middle School Mathematics Classroom." School Science and Mathematics 91.6 (October 1991): 245-46.

Havens, Lynn. "Writing To Enhance Learning In General Mathematics." Mathematics Teacher 82.7 (October 1989): 551-54.

Helton, Sonia. "I Thik The Citanre Will Hoder Laser: Journal Keeping in Math Class." Teaching Children Mathematics 1.6 (February 1995): 336-46.

Johnson, Marvin. "Writing in Mathematics Class: A Valuable Tool For Learning." Mathematics Teacher 76 (February 1983): 117-19.

Lampe, David R. "Writing in an R & D Group: The Invisible Activity." The MIT Report, Industrial Liaison Program of the Massachusetts Institute of Technology 10 (1982): 1-2.

McIntosh, Margaret. "No Time For Writing In Your Classroom?" Mathematics Teacher 84 (September 1991): 423-33.

Mett, Coreen. "Writing As a Learning Device in Calculus." Mathematics Teacher 84 (October 1987):534-37.

Mett, Coreen. "Writing In Mathematics." The Clearing House 62.7 (March 1989): 293-96.

Mumme, Judith, and Nancy Shepherd. "Implementing the Standards: Communication in Mathematics." The Arithmetic Teacher 38 (September 1990): 18-20.

Nahrgang, Cynthia, and Bruce J. Peterson. "Using Writing to Learn Mathematics." Mathematics Teacher (September 1986): 461-65.

National Council of Teacher of Mathematics. Curriculum and Evaluation Standards For School Mathematics. Reston, VA:Author, 1989.

Norwood, Karen S., and Glenda Carter. "Journal Writing: An Insight Into Students' Understanding." Teaching Children Mathematics 1.3 (November 1994): 146-48.

Pearce, Daniel L., and David M. Davison. "Teacher Use of Writing in the Junior High Mathematics Classroom." School Science and Mathematics 88.1 (1988): 6-15.

Schmidt, Don. "Writing In Mathematics Class." In Roots in the Sawdust: Writing to Learn Across the Disciplines. Ed. Anne Ruggles Gere. Illinois: National Council of Teachers of English, 1985. 104-16.

Stewart, Carolyn, and Lucinda Chance. "Making Connections: Journal Writing and the Professional Teaching Standards." Mathematics Teacher 88.2 (February 1992): 92-97.

Thaiss, Chris. "The Virginia Consortium of Faculty Writing Programs." New Directions For Teaching Learning: Teaching Writing In All Disciplines . San Francisco: Jersey-Bac, 1982.

Vacc, Nancy Nesbitt. "Planning For Instruction: Barriers to Mathematics Discussion." Arithmetic Teacher 41.6 (February 1994): 339-41.

Wadlington, Elizabeth, Joe Bitner, Elizabeth Partridge, and Sue Austin. "Have a Problem? Make the Writing-Mathematics Connection." Arithmetic Teacher 30 (December 1992): 207-9.

Watson, Margaret. "Sharing Teaching Ideas: Writing Has Place in a Mathematics Class." Mathematics Teacher 73 (October 1980): 518-19.

Waywood, Andrew. "Informal Writing-To-Learn As a Dimension of a Student Profile." Educational Studies in Mathematics 27 (1994) 321-40.

CHAPTER 3

Procedures

Introduction

In each of the following two sections, the researcher describes the make-up of the population studied, along with the procedure utilized for incorporating journal writing into a mathematics class.

The Sample

The population utilized for this study was comprised of students from Gateway Regional High School, Woodbury Heights, New Jersey. Gateway is a regional high school encompassing students from four sending districts - Wenonah, Woodbury Heights, Westville, and National Park, in grades seven through twelve. Students from Gateway come from varied socioeconomic backgrounds, from low to upper middle class. There is a 4% minority population, and 12% of the students are in special education classes.

The two classes involved in the study are Integrated Mathematics I classes. This mathematics course is an entry level course for non college-bound students, who are in need of additional preparation for the High School Proficiency Test. The experimental group was comprised of eighteen students, five of whom were mainstreamed, and met every day from 11:49 P.M. to 12:31 P.M. The control group had fifteen students, two of whom were mainstreamed, and met every day from 1:24 P.M. to 2:06 P.M.

Both classes were taught by the researcher utilizing the same method of instruction with one exception - the experimental group wrote in journals and the control group did not.

The Experiment

On Wednesday, January 31, 1996, both the experimental and control groups were administered an open-ended test (see Appendix C) consisting of six open-ended problems. The test questions were taken from a bank of open-ended questions that the researcher received from the New Jersey Department of Education. The scores on this exam were compared using an independent t-test, to determine if there was any significant difference in the level of academic achievement in responding to open-ended questions.

The experiment commenced on the first day of the third marking period - Monday, February 5, 1996. It was on this date that the researcher handed out the expectations for journal writing (see Appendix A), along with the grading policy, to the experimental group. In addition, the researcher gave several examples of the type of writing that was expected. The researcher supplied each student with a journal, that remained in the classroom at all times. Then the following criteria was explained to the students by the researcher: (1) they would write in their journals two to three times a week, for approximately five minutes at the end or the beginning of the period; (2) all entries should include the date, the question posed by the researcher, either a response to the given question or a question explaining what it was that the student did not understand, and additional comments, concerns, or questions; (3) journals would be collected once a week for the teacher to make comments or suggestions, and to answer any of the students' questions.

Two to three days a week the researcher posed a question to the experimental group (see Appendix B) during the last or first five minutes of the class period. Questions were written on the board along with the date. Students

wrote down the date, the question, and their responses. Every Friday the researcher collected the journals, wrote responses to the students' questions, and/or made appropriate comments and/or suggestions. All questions presented by the researcher were obtained from two sources - the open-ended questions from the High School Proficiency Test preparation booklets (State Department of Education), or from the teacher's edition of their textbook (Lynch and Olmstead). Students were encouraged to write down any problems or concerns they had throughout the course.

The researcher administered the posttest on Thursday, April 11, 1996, to both the experimental and control groups. An independent t-test was performed to see if there was any significant difference in the level of academic achievement in responding to open-ended questions. The posttest included five open-ended questions, that differed from the pretest, obtained from a bank of state-devised open-ended questions - the same bank of questions from the pretest.

CHAPTER 4

Analysis of Data

Introduction

The purpose of this chapter is to analyze the data generated from two sources. The first source of the data originated prior to the experiment, where both the experimental and control groups took a pretest to determine if there was a statistical correlation in academic achievement between the two groups. The second source of data was derived at the end of the experiment, where both the experimental and control groups took a posttest to ascertain if there was any significant difference in academic achievement as a result of journal writing in an Integrated Mathematics I class.

Analysis of Pretest Achievement Data

In order to determine whether the experimental and control groups were equivalent in academic achievement, a pretest (see Appendix C) was given to both groups and the scores (see Appendix E and Appendix F) were statistically analyzed. The open-ended questions from the pretest originated from two sources - Mathematics Instruction Guide: Linking Classroom Experiences to Current Statewide Assessments (New Jersey State Department of Education) and The 1992 High School Proficiency Test Holistic Scoring Guide (New Jersey State Department of Education). The mean score for the control group was 80.6 with a standard deviation of 12.999 and the mean score for the experimental group was 77.7 with a standard deviation of 16.000. Using a two-tailed independent t-test with a 0.05 level of significance, the value of t was found to be -0.5744 with 31 degrees of freedom. These results are outlined in Table 1.

Table 1

Analysis of Pretest Achievement Data

	Control Group	Experimental Group
Sample Size	15	18
Mean Score	80.6	77.7
Standard Deviation	12.999	16.000

t = -0.5744

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N_1} - \frac{S_2^2}{N_2}}} = \frac{77.7 - 80.6}{\sqrt{\frac{16.0^2}{18} + \frac{12.999^2}{15}}} = -0.5744$$

Since the value of t lies between the critical values -1.960 and 1.960 at a 0.05 level of significance, the researcher concludes that there is no significant difference in the level of academic achievement between the experimental and control groups; therefore the two groups are academically equivalent.

Analysis of Posttest Achievement Data

Throughout the experiment, the experimental group wrote in journals two to three times a week, and the control group did not write in journals. Aside from the inclusion of journals in the experimental group, the method of instruction for both groups was the same. In order to ascertain if there was a significant increase in academic achievement as a result of journal writing, the researcher gave both groups a posttest (see Appendix D), utilizing the same format and the same sources as the pretest. Statistical analysis was performed

on the posttest scores for both groups (see Appendix G and Appendix H). The mean score for the control group was 81.6 with a standard deviation of 15.267, and the mean score for the experimental group was 81.8 with a standard deviation of 11.548. Using a two-tailed independent t-test with a 0.05 level of significance, the value of t was found to be 0.0418 with 31 degrees of freedom. The results are outlined in Table 2.

Table 2

Analysis of Posttest Achievement Data

	Control Group	Experimental Group
Sample Size	15	18
Mean Score	81.6	81.8
Standard Deviation	15.267	11.548

t = 0.0418

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} = \frac{81.8 - 81.6}{\sqrt{\frac{11.548^2}{18} + \frac{15.267^2}{15}}} = 0.0418$$

Since the value of t lies between the critical values -1.960 and 1.960 at a 0.05 level of significance, the researcher concludes that there was no significant difference in academic achievement between the experimental and control groups as a result of the introduction of journals in an Integrated Mathematics I class. Therefore, the null hypothesis was accepted.

CHAPTER 5

Summary, Conclusions and Recommendations

Introduction

Incorporated in this chapter is an evaluation and interpretation of the data, as well as the formulation of conclusions based on the findings. A comparison is made on the conclusions as they relate to the literature and research that was perused for this study. Finally, the researcher makes recommendations that may enhance further study of the research topic, discusses unexpected results, and outlines factors that may have affected the given findings.

Summary of Findings

After journal writing was introduced to one of two academically equivalent Integrated Mathematics I classes for a period of eight weeks, the post-test indicated that there was no significant difference in academic achievement. The mean score for the control group was 81.6 with a standard deviation of 15.267, and the mean score for the experimental group was 81.8 with a standard deviation of 11.548. Using a two-tailed independent t-test, this resulted in a t-score of 0.0418 at a 0.05 level of significance with 31 degrees of freedom. Since this t-value lies between the critical values of -1.960 and 1.960, there was no significant difference in academic achievement between the experimental and the control groups. Therefore, the null hypothesis was accepted.

Conclusions

Based on the findings of this study, utilizing journals three or more times a week did not indicate any significant difference in academic

achievement. These findings do not concur with previously published studies, which indicate a significant increase in academic achievement as a result of journal writing on a regular, routine basis (Stewart and Chance 93-5; Borasi and Rose 347-51). However, these studies were conducted in higher level classes than Integrated Mathematics, and were conducted over a period of at least one year, as opposed to eight weeks for the given experiment. In addition, many of the other studies were concerned with determining increases in attitude and critical thinking skills, and decreases in mathematical anxiety, rather than changes in academic achievement.

Recommendations

Most of the findings in the literature and research were based on long-term studies and observations, particularly in light of the fact that writing in mathematics is not a prevalent procedure; as a result, it takes some time to acclimate students to writing. In an eight week study, the researcher estimates that during the first two weeks students are grasping for words, trying to stray from the mechanics of mathematics and into the thinking behind the 'why' of what they are doing. Once the researcher provided students with feedback in their journals, each week the entries demonstrated more descriptions of thought processes and less reiterations of the concepts presented. Thus a year-long study would go far beyond the learning stages of writing, and as the research indicates, the more feedback given to students the more the writing improves. In addition, the aforesaid study involved low-ability students who usually require long periods of time to become accustomed to any new teaching technique.

An interesting outcome occurred with this study that needs attention. There were seven mainstreamed students in the study - five in the experimental

group, and two in the control group. Initially, this was a concern with the researcher since writing was a potential barrier with the mainstreamed students. However, Table 3 and Table 4 outlines the results of these seven students.

Table 3

Pretest and Posttest Scores For Mainstreamed Students in the Experimental Group

	Pretest Score	Posttest Score
Student A	67	84
Student B	56	78
Student C	72	89
Student D	61	67
Student E	72	89
Mean Score	65.6	81.4

Table 4

Pretest and Posttest Scores For Mainstreamed Students in the Control Group

	Pretest	Posttest
Student A	83	72
Student B	44	39
Mean Score	63.5	55.5

Except for one student in the experimental group, scores increased substantially. In the control group, however, both students' scores went down. The student with an initial grade of forty-four does have lower ability than all of the mainstreamed students in the experimental group, but the other student in the control group had about the same ability level as those in the experimental group. It is the researcher's recommendation that further studies should be made into the use of journal writing with mainstreamed students.

Another recommendation by the researcher would be to introduce journal writing at the beginning of the year - a time when everything else is new to the students, so that an added feature such as journals would be less likely to be questioned by the students. In addition, if one were to utilize journals, the researcher recommends that time be allocated to write in the journals at least three times a week and that the teacher provides feedback to the student at a minimum of once a week. It was the researcher's experience that the students did not rebel against the journals. In fact the researcher gained a much better rapport with the class using journals than she did with the class not using journals, even though the rapport with both classes was equivalent prior to the experiment. In addition, it is the researcher's recommendation to give the students a written prompt (on the board or a piece a paper) so that they have a clear direction to follow. As a result of using this procedure, the students never hesitated about what to write.

In summary, although the experiment was too short to procure more positive results, journal writing did seem to improve learning for mainstreamed students, ameliorate the student-teacher rapport, and provided a positive and friendly environment for learning.

APPENDIX A

JOURNAL WRITING CRITERIA

Integrated Math I
Journal Writing Criteria

During the 3rd and 4th marking periods, you will be required to keep a math journal. You will be writing in your journals 3-4 times a week, which will represent 10% of your grade during the 3rd and 4th marking periods.

The purpose of the journal is as follows:

1. To put mathematical concepts into your own words in order for you **think** about what you learned and apply what you learn to a real-life situation.

2. To express your frustrations with the mathematics and to ask any questions you may have as you're explaining the concepts.

3. To help me determine what it is that you do not understand, so that I can target in on your difficulties and help you succeed. When I collect the journals, I will answer your questions and make any necessary comments.

4. To help all of you become better thinkers and problem solvers.

My expectation from your journals is that you:

1. write in your journals every time I give you a prompt,

2. even if you can't answer the question, express what it is that you're having difficulty with,

3. take this seriously so that you will learn from writing in your journal.

APPENDIX B

JOURNAL ENTRIES

JOURNAL ENTRIES

1. What are your feelings toward math? Explain what you like or dislike about math.

2. Explain in your own words what an *equation* is.

3. Write in words how you would solve: $x + 9 - 23 = 11$. Check your answer to see if you were correct.

4. Explain what it means to solve an equation. How do you know if your answer is correct?

5. Explain how you would solve: $2x = -16$. Why did you choose that operation?

6. Write a definition in your own words of the following:

   a) equation

   b) open sentence

   c) true equation

   d) false equation

7. Write an equation that requires addition to solve it. Then write a word problem that will go along with your equation.

8. When solving a word problem, what would you let the variable represent? How does an equation help you solve a problem?

9. When you look at an equation, how do you decide whether to use addition, subtraction, multiplication, or division? Use examples as needed.

10. Think about what we did with equations on the graphing calculator.

    a) What did the solution $x = 3$ mean for the graph of the equation $2x - 1 = 5$?

    b) Did the graphing calculator help you see what solving an equation means? Why or why not?

11. Explain the difference between an expression and an equation. Give an example of each.

12. Explain in words how you would solve $2x - 5 = 3x + 7$.

13. Explain how you would use a reciprocal to solve: $(2/3)x = -8$.

14. Suppose you were converting Fahrenheit temperatures to Celsius temperature. You had the following formula to convert from Celsius to Fahrenheit:

$$F = (9/5)C + 32$$

Explain how you would solve this formula for C so that it would be easier to use.

15. What is a formula? Explain a real-life situation where you would need a formula (even if you don't know the exact formula).

16. Explain in your own words how you would graph the inequality:

$$-5 > e - 6$$

17. Write a paragraph summarizing the rules for solving inequalities. Use an example as an aid.

18. Describe the meaning of a ratio. Include a statement of the ratio in words; then write a ratio three different ways, using symbols. Describe a real-life situation where a ratio might be used.

19. Explain the meaning of this statement: "*A rate is always a ratio, but a ratio is not always a rate.*" Give an example of a ratio that is a rate.

20. Explain how you could determine whether two ratios are equivalent. Give examples.

21. What does it mean to design a 'scale drawing'? Explain the process you would have to go through to come up with a scale drawing.

22. Think about the scale drawings you did in class. Explain some of the problems you went through. What mathematics did you have to use to design your

scale drawings?

23.Construct a rectangle having an area of 12 in^2 and a perimeter of 16 in. Label all sides. Show the work that will prove that the area is 12 in^2 and the perimeter is 16 in.

24. Explain in words how you would do the following:

a) Write 7.4% as a decimal.

b) Write (5/8)% as a fraction.

c) Write 5.38 as a percent.

d) Write 1/15 as a percent.

25. If you were in a store and didn't have access to a calculator, explain how you would find the price of an item that was $48.99 with a 20% discount.

26. Give a real-life example, other than discount, where you would use percent. Explain the process you would go through to solve a real-life problem.

APPENDIX C

PRETEST

Integrated Mathematics I
PRETEST
Open-Ended Questions

DIRECTIONS: Write your answers in the spaces provided. For each question, give a detailed explanation. You will be graded on the quality of your thinking, as shown by your explanations, as well as on the correctness of your responses.

1. The math exam scores for the 21 students in Mr. Johnson's class were:

72 85 90 68 72 91 84 70 61 89 82 84 86 71

61 89 70 94 70 78 93

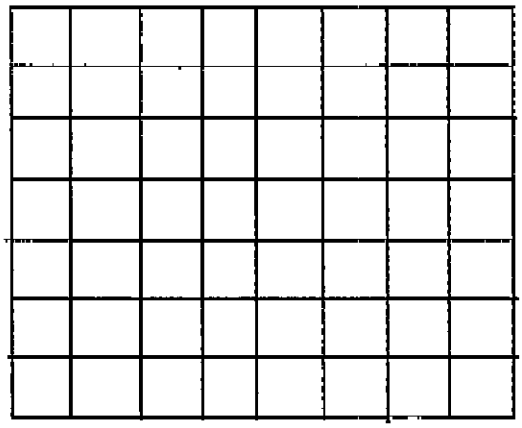
a) What is the mean score?

b) What is the median score?

c) What is the mode?

d) Use the grid below to make a bar graph showing the frequency or number of scores in each of the score ranges 60-64, 65-69, 70-74, etc.

e) Which is the best indicator of this class's performance on the exam - the mean, median, or mode? **Explain** your answer.



2. Estimate 198.76 X 307 **IN YOUR HEAD**. Explain in writing what your estimate is and how you got your answer.

FOR PROBLEMS 3 - 6, CHOOSE 3 PROBLEMS.

3. At a large family gathering, the heights of the family members were recorded in inches. The data are shown below:

46	61	39	70	75	50	47	55	68	72	74	47	48
68	58	68	54	72	61	67	55	52	50			

a) Draw a stem-and-leaf plot for the given data.

Answer the following questions on your stem-and-leaf plot
The heights of how many people fall within each interval?

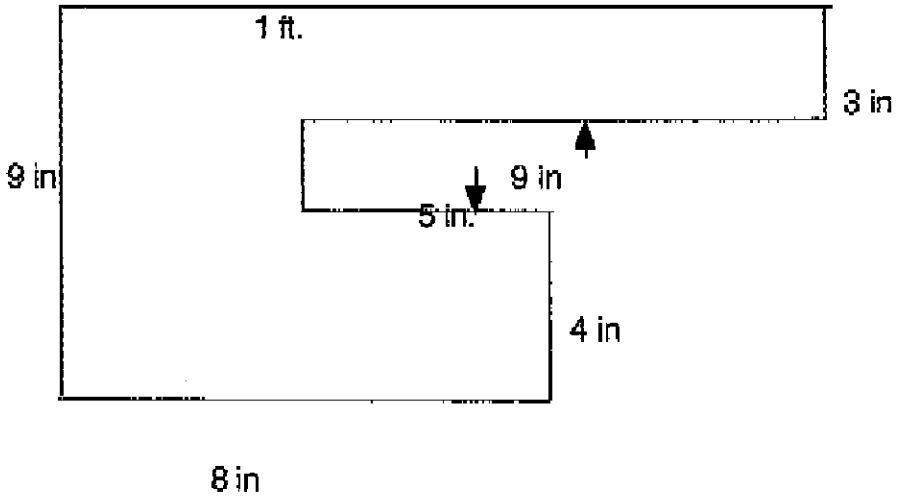
b) 40-49 in _____
c) 50-59 in _____
d) 70 in or more _____

e) Explain why a stem-and-leaf plot is useful for listing data.

4. Max, Burt, and Laura each play one sport. One plays football, one plays basketball, and one plays baseball. Bert is a poor student. Laura is an only child and a cheerleader for the football team. Each basketball player has a brother or sister, and all of them are good students. What sport does each person play?

5. There are 9 math teams that are competing in a math competition. Each team must compete against every other team once. How many competitions are there?

6. Find the perimeter of the figure below. (Figure is not drawn to scale.)



APPENDIX D

POSTTEST

Integrated Math 1
POSTTEST
Open-Ended Question Test

DIRECTIONS: Write your answers in the space provided. For each question, give a detailed explanation. You will be graded on the quality of your thinking, as shown by your explanations, as well as on the correctness of your responses.

1. The number of feet of cable needed for an elevator depends on the number of stories (floors) in the building it serves. Suppose that $c = 20s + 25$, where **c** is the number of feet of elevator cable and **s** is the number of stories.

a) How many feet of cable are needed for a 10-story building?

b) How tall a building needs 325 feet of cable?

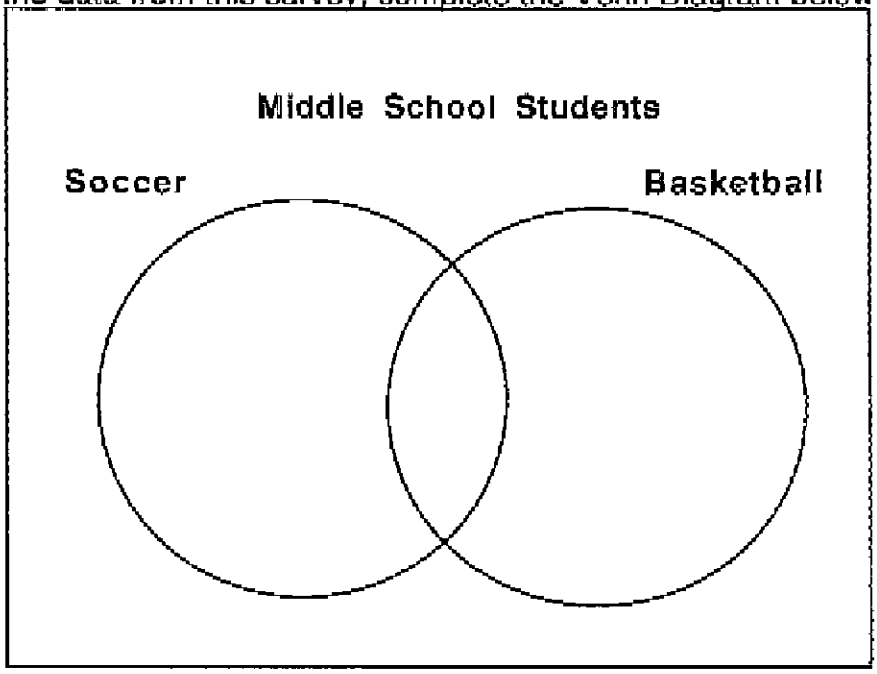
c) In the equation $c = 20s + 25$, what does the 20 represent (as it relates to the building).

2. On a number line, what number corresponds to the point that is 1/4 of the distance from -2 to -18? Draw a number line and graph this point. Explain the process you used to find the solution.

3. A survey of 120 middle school students indicated the following:

70 played soccer
40 played basketball
20 played both soccer and basketball

a) Using the data from this survey, complete the Venn Diagram below:



b) What percent of the students played neither soccer nor basketball?

c) Give an explanation of the process you used to find the answer.

4. What is the units (ones) digit of the number that is represented by 4^{18}? Explain your answer.

5. Suppose you have received 3 scores during a problem solving unit. They are as follows:

Test:	85 (out of 100)
Portfolio:	75 (out of 100)
Observations:	92 (out of 100)

You will receive 10 points extra credit if you solve this problem correctly. The extra credit can be added to any one of the 3 scores listed above. Certainly you would like to do this in the way that produces the highest possible average for you in this unit. Your task is to decide which score the extra credit should be added to in order to get the highest possible average. You must explain in detail why your explanation makes sense. Cite examples in your explanation.

APPENDIX E

PRETEST SCORES (EXPERIMENTAL GROUP)

PreTest Experimental
Group

Student	Sex	Score
A	Male	89
B	Male	67
C	Female	94
D	Male	56
E	Female	94
F	Female	94
G	Female	61
H	Male	72
I	Male	94
J	Female	72
K	Female	78
L	Male	72
M	Male	72
N	Male	100
O	Male	61
P	Male	44
Q	Female	89
R	Female	89

Mean = 77.7

APPENDIX F

PRETEST SCORES (CONTROL GROUP)

Pretest Control
Group

Student	Sex	Score
A	Male	72
B	Female	94
C	Male	89
D	Female	89
E	Male	72
F	Male	89
G	Male	94
H	Male	72
I	Female	83
J	Male	44
K	Male	89
L	Male	72
M	Male	78
N	Female	89
O	Male	83

Mean = 80.6

APPENDIX G

POSTTEST SCORES (EXPERIMENTAL GROUP)

Posttest Experimental Group

Student	Sex	Score
A	Male	89
B	Male	84
C	Female	94
D	Male	78
E	Female	89
F	Female	94
G	Female	67
H	Male	67
I	Male	94
J	Female	72
K	Female	72
L	Male	89
M	Male	89
N	Male	94
O	Male	61
P	Male	67
Q	Female	78
R	Female	94

Mean = 81.8

APPENDIX H

POSTTEST SCORES (CONTROL GROUP)

Post-Test Control
Group

Student	Sex	Score
A	Male	61
B	Female	94
C	Male	94
D	Female	89
E	Male	89
F	Male	83
G	Male	94
H	Male	83
I	Female	72
J	Male	39
K	Male	94
L	Male	72
M	Male	89
N	Female	83
O	Male	89

Mean = 81.6

WORKS CITED

Artzt, Alice F. "Integrating Writing and Cooperative Learning in the Mathematics Class." Mathematics Teacher 81.2 (February 1992): 80-85.

Atherton, Christy, et al. "Keeping Math Journals." Instructor 101.8 (April 1992): 46-47.

Bell, Elizabeth and Ronald N. Bell. "Writing and Mathematical Problem Solving: Arguments in Favor of Synthesis." School Science and Mathematics (1985): 210-11.

Borasi, Raffaella and Barbara J. Rose. "Journal Writing and Mathematics Instruction." Educational Studies in Mathematics 20 (1989): 347-65.

Brown, Nancy. "Writing Mathematics." Arithmetic Teacher 41.1 (September 1993): 20-21.

Burton, Grace M. "Writing As a Way of Knowing In a Mathematics Education Class." Arithmetic Teacher 33 (December 1985): 40-45.

Calkins, Lucy. The Art of Teaching Writing. Portsmouth, NH: Heinemann Books, 1986.

Ford, Margaret I. "The Writing Process: A Strategy For Problem Solvers." Arithmetic Teacher 38.3 (November 1990): 35-38.

Good, Carter V. Dictionary of Education. New York: McGraw-Hill Book Company, Inc., 1959.

Good, Carter V. and Winifred Merkel. Dictionary of Education. 3rd ed. New York: McGraw-Hill Book Company, Inc., 1973.

Graves, Donald H. Writing: Teachers and Children at Work. Exeter, NH: Heinemann Educational Books, 1983.

Haggerty, Donald J. "Writing In the Middle School Mathematics Classroom." School Science and Mathematics 91.6 (October 1991): 245-46.

Havens, Lynn. "Writing To Enhance Learning In General Mathematics." Mathematics Teacher 82.7 (October 1989): 551-54.

Helton, Sonia. "I Thik The Citanre Will Hoder Laser: Journal Keeping in Math Class." Teaching Children Mathematics 1.6 (February 1995): 336-46.

Johnson, Marvin. "Writing in Mathematics Class: A Valuable Tool For Learning." Mathematics Teacher 76 (February 1983): 117-19.

Lampe, David R. "Writing in an R & D Group: The Invisible Activity." The MIT Report, Industrial Liaison Program of the Massachusetts Institute of Technology 10 (1982): 1-2.

Lynch, Chicha, and Eugene Olmstead. MATHMATTERS An Integrated Approach. Ohio: South-Western , 1995.

McIntosh, Margaret. "No Time For Writing In Your Classroom?" Mathematics Teacher 84 (September 1991): 423-33.

Mett, Coreen. "Writing As a Learning Device in Calculus." Mathematics Teacher 84 (October 1987):534-37.

Mett, Coreen. "Writing In Mathematics." The Clearing House 62.7 (March 1989): 293-96.

Miller, Diane. "Writing to Learn Mathematics." Mathematics Teacher. (October 1991): 516-521.

Mumme, Judith, and Nancy Shepherd. "Implementing the Standards: Communication in Mathematics." The Arithmetic Teacher 38 (September 1990): 18-20.

Nahrgang, Cynthia, and Bruce J. Peterson. "Using Writing to Learn Mathematics." Mathematics Teacher (September 1986): 461-65.

National Council of Teachers of Mathematics. Assessment Standards for School Mathematics. n.d.

National Council of Teachers of Mathematics. Curriculum and Evaluation Standards For School Mathematics. Reston, VA:Author, 1989.

New Jersey State Department of Education. Mathematics Instructional Guide: Linking Classroom Experiencse to Current Statewide Assessments. Trenton: 1996.

Norwood, Karen S., and Glenda Carter. "Journal Writing: An Insight Into Students' Understanding." Teaching Children Mathematics 1.3 (November 1994): 146-48.

Pandey, Tej. A Sampler of Mathematics Assessment. California Assessment Program. Sacramento, CA: California Department of Education, 1991.

Pearce, Daniel L., and David M. Davison. "Teacher Use of Writing in the Junior High Mathematics Classroom." School Science and Mathematics 88.1 (1988): 6-15.

Schmidt, Don. "Writing In Mathematics Class." In Roots in the Sawdust: Writing to Learn Across the Disciplines. Ed. Anne Ruggles Gere. Illinois: National Council of Teachers of English, 1985. 104-16.

Stewart, Carolyn, and Lucinda Chance. "Making Connections: Journal Writing and the Professional Teaching Standards." Mathematics Teacher 88.2 (February 1992): 92-97.

Thaiss, Chris. "The Virginia Consortium of Faculty Writing Programs." New Directions For Teaching Learning: Teaching Writing In All Disciplines . San Francisco: Jersey-Bac, 1982.

Vacc, Nancy Nesbitt. "Planning For Instruction: Barriers to Mathematics Discussion." Arithmetic Teacher 41.6 (February 1994): 339-41.

Wadlington, Elizabeth, Joe Bitner, Elizabeth Partridge, and Sue Austin. "Have a Problem? Make the Writing-Mathematics Connection." Arithmetic Teacher 30 (December 1992): 207-9.

Watson, Margaret. "Sharing Teaching Ideas: Writing Has Place in a Mathematics Class." Mathematics Teacher 73 (October 1980): 518-19.

Waywood, Andrew. "Informal Writing-To-Learn As a Dimension of a Student Profile." Educational Studies in Mathematics 27 (1994) 321-40.