The relationship between journal writing and achievement in mathematical measurement and place value/regrouping among primary school children  
by Carmi Ray Wells  

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education  
Montana State University  
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Abstract:  
This study investigated the relationship of math instruction in measurement and place value/regrouping with journal writing for students in grades one, two and three. Of interest to this study was the interaction of gender and prior achievement to determine if the method of instruction benefited a particular group.  

The study consisted of two parts. The procedures for both parts included mathematics instruction with journal writing with the experimental group and mathematics instruction with no journal writing for the control group. The major difference between the two parts of the study was that the first part involved instruction in measurement and the second involved instruction in place value/regrouping.  

A total of 250 students in ten classrooms made up the population of the study, with the experimental group and the control group each consisting of one first grade, two second grade and two third grade intact classes. Equality of groups was determined using a one-way analysis of variance to test six null hypotheses for each part of the study. The groups were found to be equal in prior knowledge of measurement but not equal in prior knowledge of place value/regrouping.  

Twenty-one null hypotheses were tested in each part the study to determine if a method of instruction resulted in a significant difference in the mean gain score between any particular groups. A three-way analysis of variance was used to analyze data in measurement, since the groups were equal, resulting in retention of eighteen hypotheses and rejection of three hypotheses. To adjust for unequal groups, an analysis of covariance using pretest scores as a covariate in place value/regrouping resulted in retention of eighteen hypotheses and rejection of three hypotheses.  

The major conclusions made in this study were: 1. In addition to the grade levels being equal in prior knowledge of measurement but not in prior knowledge of place value/regrouping, ten percent of the students demonstrated high prior knowledge in one topic and low prior knowledge in the other; 2. Males and females made similar achievement gains in both measurement and place value/regrouping regardless of which method of instruction was used; 3. The method of instruction made no significant difference in measurement gain scores in grades one, two and three; 4. An observation was made that third grade students lowest in prior achievement in place value/regrouping scored significantly higher gains when they received mathematics instruction with journal writing; 5. The researcher found significantly higher achievement gains regardless of method of instruction for students in grades one, two and three that were identified as having the least prior knowledge in measurement and students in grades one and three for students having the least prior knowledge in place value/regrouping.
THE RELATIONSHIP BETWEEN JOURNAL WRITING AND ACHIEVEMENT IN
MATHEMATICAL MEASUREMENT AND PLACE VALUE/REGROUPING
AMONG PRIMARY SCHOOL CHILDREN

by

Carmi Ray Wells, I

A thesis submitted in partial fulfillment
of the requirements for the degree
of
Doctor of Education

MONTANA STATE UNIVERSITY
Bozeman, Montana
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Signature  

Date  

June 7, 1986
This thesis is dedicated to Sandra, Jennifer, Carmi II, Jessica, and Emory, who always maintained support and belief in me, while I spent untold hours away from them.
Carmi R. Wells was born on June 23, 1947, in Bombay, New York, son of Elbert E. and Myrna Phelps Wells. Educated in upstate New York, he attended the State University of New York at Oswego, New York where he received the Bachelor of Science degree in Elementary Education in 1968, a Master of Education degree in 1977, and a Certificate of Advanced Study in Educational Administration in 1981.

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Mr. Wells is married to Sandra Huling Wells, and they together have two daughters, Jennifer Lee and Jessica Marie, and two sons, Carmi Ray and Emory Eugene.
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CHAPTER 1

THE DEVELOPMENT OF THE PROBLEM

Introduction

Contemporary mathematics educators across our nation have recognized that mathematics is directly linked with language. Hicks et al. (1970) called mathematics a language which is used to communicate qualitative characteristics of objects and ideas. Shepherd and Ragan (1982) viewed mathematics as a communication system that necessitated comprehension on the part of the learner. Perhaps James Moffett and Betty Jane Wagner, co-authors of Student-Centered Language Arts and Reading, K-13: A Handbook For Teachers, said it best in 1983 when they concluded:

The real kinship is between English and math, because both are symbol systems by means of which we encode experience, math being a special notation that purifies and extends ordinary language. This kinship is rightly expressed in the three Rs. The native language codes experience qualitatively, in words, whereas mathematical symbols encode it quantitatively, in numbers. As with other languages, we can translate between math and English. We can read equations out loud in English, for example, even though none of the symbols are written in English, and sometimes when no equivalent symbol exists for a concept in math we have to talk around it until we explain it (p. 41).

Educators have commenced to connect mathematics and the four components of language, namely listening, speaking, reading and writing. For years teachers have stressed the need for elementary
students to "listen" closely to see if the problem was asking for "the difference" or "the sum". Teachers also recommended that the students utilize "speaking" skills by orally reciting practice drills such as the multiplication tables. Educators stressed "reading" skills as elementary students were given word problems to solve. Only recently have educators begun to explore the connection between writing and mathematics (e.g., Johnson, 1983).

The recent interest in writing in mathematics resulted from the consideration of writing as a process. Traditionally in our schools, writing has been considered a product of communication; now it is also being viewed as a functional process that develops and organizes thinking skills (Applebee, 1977; Calkins, 1978, 1980b; Graves, 1978; Atwell, 1985; Fulwiler, 1982; Shaw, 1983; Hays, 1983; Thaiss, 1984; Klein, 1985; Langer et al., 1985). Exploration has begun to determine possible effects that the writing process has on achievement across the curriculum. James E. Miller, Jr., author of Word, Self, Reality: The Rhetoric of the Imagination, 1972, concluded:

For writing is discovery. The language that never leaves our head is like colorful yarn, endlessly spun out multicolored threads dropping into a void, momentarily compacted, entangled, fascinating, elusive ...Indeed, writing is largely a process of choosing among alternatives from the images and thoughts of the needless flow, and this choosing is a matter of making up one's mind, and this making up of one's mind becomes in effect the making up on one's self (p. 1).

A review of the literature revealed reports of positive effects resulting from integrating writing in various curricular areas. Wotring and Tierney (1982) reported increased retention of science
information for students who received science instruction that integrated writing. Integrating writing in reading instruction resulted in increased reading skill acquisition (Calkins, 1980a; Rubin, 1980; Rhodes, 1981; Smith, 1979). Instruction in mathematics that integrated writing has also resulted in increased math achievement (Skillman, 1972; Watson, 1980; Johnson, 1983; Shaw, 1983; Evans, 1984). Atwell (1985) and Fulwiler (1982) claimed that the integration of writing in any area of the curriculum would improve achievement in that area.

Although the literature review revealed positive effects between writing activities integrated into various subject areas, the studies predominantly dealt with students other than at the primary levels. Skillman (1972) and Fulwiler (1982) reported on college students. Watson (1980), Wotring et al. (1982), and Johnson (1983) reported on high school students. Shaw (1983) studied junior high school students, while Atwell (1985) and Evans (1984) wrote about students in the intermediate grades of fourth, fifth and sixth. Few studies examined mathematics instruction with integrated writing for primary school students.

One recent attempt to investigate the effects of writing in mathematics classes for primary school students examined some interesting perspectives, but appeared to this researcher to be far too generalized and as such limited. In this study, Ferguson and Fairburn (1985) investigated mathematical learning for exceptional school students in second grade. They reported increased gains in achievement for problem solving in mathematics as a result of integrating math
instruction with listening, speaking, reading and writing. Although they concluded that the language-experience approach was an effective teaching strategy to use for instruction related to problem solving in math for remedial students, their study contained serious limitations. They did not isolate the language skills taught so that they could determine the effect of each, nor did they provide a group for comparison with the experimental group. Not only did their study fail to employ a control group, but it contained a sample size of only fifteen students, all of whom were in a remedial math program. While the ideas upon which their study was based appeared sound, the design of their study made it very difficult to generalize to the school population at large.

Although a review of the literature failed to reveal other studies on primary school students writing in mathematics, it did reveal many reports from authorities advocating writing in primary school (Graves, 1975, 1978; Rhodes, 1981; Florio, 1982; Friedman, 1985; Hipple, 1985). These authorities mentioned several types of writing that are appropriate for primary school students, including sentences, friendly letters, stories, math word problems and journals. Journals, often referred to as diaries or learning logs, were highly recommended as a language arts activity to use in other disciplines. Journals help primary students build a positive self-concept, develop and organize thinking skills and provide an outlet to express ideas and feelings (Canfield et al., 1976; Graves, 1978; Y. Goodman, 1978; Milz, 1980; Hipple, 1985; Klein, 1985).
The Importance of the Study

The effect of writing as a process for learning and developing thinking skills has begun to be explored across our nation. This trend was observed at different school levels where writing has been integrated with instruction in various subjects, including mathematics. In fact, reports indicated that writing enhances mathematics achievement for students above the primary school level. Reviewing the literature, however, revealed few scientific studies conducted with primary school students where mathematics instruction was integrated with writing.

Teachers have recently been advised to encourage writing in the primary grades using a variety of activities. Journals, in particular, were recommended as an excellent type of writing activity appropriate for this age level. It was reported that writing in journals would improve writing skills, as well as improve thinking skills in the subject being written about. No research was found that had been conducted with primary school students to measure the effects of journal writing in a specific subject area.

Mathematics, an elementary subject that requires thinking skills which might be facilitated by journal writing, has had priorities established. Problem solving is one skill area of elementary mathematics that has received much attention during the last decade. Other priorities have also been identified. Results of the National Assessment of Mathematics for Elementary Schools, conducted in 1981 and 1983, and published in the respective editions of the Arithmetic
Teacher, indicated a priority need for improvement of teaching and learning in the areas of measurement and place value/regrouping. Furthermore, these results indicated that males scored slightly higher than females on measurement, while females outscored males on place value/regrouping. An earlier study by Balik (1976) reported no interaction between gender and cognitive learning style in mathematics for elementary school students. Gender appeared to remain an issue that is inconclusive regarding certain areas of study and with certain styles of instruction.

Statement of the Problem

The problem addressed by this study was to determine if there is a significant difference in gain score means of primary students who receive math instruction with journal writing and primary students who receive math instruction with no journal writing. The study was two-fold in that it investigated this problem with two topics in mathematics, namely measurement and place value/regrouping.

Specifically, the study was designed to compare the measurement gain scores of the experimental group with those of the control group, and to make a similar comparison using place value/regrouping gain scores. The basic assumption was that a treatment effect would result in more (or less) change in the experimental group than in the control group. Using a three way analysis of variance design, additional hypotheses were tested to analyze possible changes based on the independent variables of gender, grade level and prior achievement.
Definition of Terms

The following terms are defined for the purpose of this study:

**Achievement.** Gains in the mathematical skill areas of measurement and place value/regrouping calculated by subtracting pretest scores from posttest scores to yield gain scores.

**Prior Achievement Level.** The level of performance in mathematical measurement and/or place value/regrouping before instruction, such that high indicates a pretest score that is equal to or greater than one standard deviation above the mean, medium indicates a pretest score less than one standard deviation above the mean but greater than one standard deviation below the mean, and low indicates a pretest score less than one standard deviation below the mean.

**Primary students.** Students in grades one, two and/or three.


**Place value/regrouping.** Renaming quantities in expanded notation form such that a transfer of quantities results in equivalent numerical values. For example, 38 in expanded notation form would be 3 tens and 8 ones; whereas, in regrouped equivalent format 38 would become 2 tens and 18 ones (Ashlock et al., 1983).

**Measurement.** The process of comparing an attribute of a physical object to some unit selected to quantify that attribute (Ashlock et al., 1983).

**Integration of writing.** The incorporation of the writing
process into mathematics instruction in the form of student math journals.

**Math journals.** A series of daily written entries, such as a diary or a log, which reflects on the mathematics being studied.

**Prediction entry.** The student writes a prediction of the new unit or topic assigned, explaining what it will be about and perhaps how it will be taught. It should be future tense and may include their expectations about feelings.

**Summary entry.** The student writes an explanation of what was learned that day.

**Feeling entry.** The student writes about how he/she felt during and after the lesson, when a feeling of success, breakthrough, or failure occurred, and possibly why. Descriptions may include what was frustrating and what finally helped him/her solve it, but should not be just a repeat of the teacher's explanation.

**Process entry.** The student writes a description of how he/she solved a particular problem dealing with the lesson topic, to include the steps involved, as opposed to just how he/she felt.

**Story-problem entry.** The student applies learnings gained by writing his/her own story-problem on today's lesson or the unit of study.

**Reflection entry.** The student writes about how writing on a topic in the journal has helped him/her learn that topic, and also writes to correct or confirm earlier predictions about the topic being studied.
Writing. The ability to employ pen or pencil and paper to express ideas symbolically so that the representations on the paper reflect meaning and content capable of being communicated to another (Klein, 1985).

General Procedures

The general procedures that were followed are noted below.

1. An extensive review of the literature was completed. Specifically, the review concentrated on literature that was related to mathematical achievement for primary age students in the skill areas of measurement and place value/regrouping and literature related to the process of writing. This review addressed research and reports in the following subcategories:

   a. Literature related to measurement.
   b. Literature related to place value/regrouping.
   d. Literature related to writing across the curriculum.

2. Students in ten primary grade classrooms from Bozeman Public School District No. 7, Bozeman, Montana were selected to participate in this study. The ten classrooms consisted of two first grade classes, four second grade classes, and four third grade classes. The students were enrolled in two of the four elementary schools in Bozeman, namely Irving Elementary School and Emerson Elementary School.

3. Students in one first grade class, two second grade classes, and two third grade classes composed the experimental group with an
equal class distribution forming the control group. Groups were designated as follows:

a) experimental - those primary students receiving instruction in the mathematical skill areas of measurement and place value/regrouping, where math instruction integrated writing in daily math journals and

b) control - those primary students receiving instruction in the mathematical skill areas of measurement and place value/regrouping, where math instruction included no writing in daily math journals.

4. Both the experimental and the control groups were given pretests in measurement in November, 1985 and pretests in place value/regrouping in January, 1986. The results of the pretests were used to determine the equivalence of groups and to determine the beginning level of achievement in both skill areas of mathematics. The pretests used were the Primary Math Tests for Measurement (PMTM) and the Primary Math Test for Place Value/Regrouping (PMTP), both of which were developed and field-tested by the researcher.

5. Teachers of students in the experimental group participated in training sessions conducted by two experts from Montana State University in Bozeman. One expert provided in-depth training for teachers regarding instruction in journal writing for primary grade level students. The other expert assisted in some of the training, specifically regarding instruction in writing mathematical story problems. No training sessions were required for the teachers of
students in the control group.

6. Math instruction for students in the experimental and control groups, for both skill areas of measurement and place value/regrouping, was based on the Math Around Us textbook series published by Scott, Foresman and Company in 1975. Students in both groups received instruction based on identical pages from their respective grade level texts. Math manipulatives to develop conceptual understandings were used independently by all the teachers involved to provide concrete referants for students in both groups. Directly following the pretest, all teachers provided three weeks of instruction in the skill area of measurement, and six weeks of instruction for the skill area of place value/regrouping, with the exception that first grade teachers only provided three weeks of instruction for the skill area of place value/regrouping. Time periods of daily instruction in both skill areas for both the experimental group and the control group were established at thirty minutes for first grade, forty minutes for second grade, and forty-five minutes for third grade. Journal writing was integrated into math instruction during the time period established.

7. The treatment for the experimental group involved each student writing daily math journal entries related to the mathematics being studied. Six specific types of entries were assigned: prediction, summary, feeling, process, story problem, and reflection. These entries were assigned to students in all three grade levels according to a set schedule (Figure 2). Student math journals were read by each teacher once a week. Also, student math journals were sent home once each week for parents to read and to write a parent
entry. These entries were intended for feedback and motivational purposes for students.

8. Directly following the instruction for the math skill area of measurement and the math skill area of place value/regrouping, both the experimental and control groups received posttests for each area of skills. The posttests for measurement were given in December, 1985, and the posttests for place value/regrouping were given in February, 1986. Comparison of pretest and posttest scores for each student in both groups provided gain scores of achievement for each skill area. The primary objective of the study was to determine if a significant difference in gain score means resulted between students in the experimental group and students in the control group. Additional analyses were conducted to determine if a significant difference in gain score means occurred using the independent variables of gender, grade level and prior achievement.

Limitations of the Study

This study was limited in the following ways:

1. The population of this study was limited to two first grade classes, four second grade classes, and four third grade classes in two elementary schools in the Bozeman Public School District No. 7, Bozeman, Montana.

2. Instruction in mathematics for the experimental group and the control group was limited to three weeks on measurement skills for all primary grade students, three weeks on place value/regrouping skills
for first grade students, and six weeks on place value/regrouping skills for second and third grade students.

3. Instruction in the mathematical skill area of measurement was limited to units of distance, time, and capacity, and did not include units of weight, temperature, and money.

4. All pretest and posttest questions were limited to representative samples of measurement skills and place value/regrouping skills from the Mathematics Around Us test booklets designed for grades one, two and three, and published by the Scott, Foresman and Company in 1975. Therefore, the pretests and posttests were limited to assessing only the achievement and thinking skills reflected by the questions in the test booklets, which were designed to measure content from the Scott, Foresman and Company textbook series, Mathematics Around Us, published in 1975.

5. The review of the literature was limited to research reports published from the period of 1900 to 1986. It was further limited to achievement in mathematics in the skill areas of measurement and place/value regrouping. Generalizations drawn from this study reflected these limitations.
CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The literature was reviewed for research relevant to mathematics instruction and student-centered writing appropriate for primary grade level students. While reviewing the literature, specific emphasis was placed on searching for research reports centering on mathematics instruction in measurement and place value/regrouping, and also on reports centering on journal writing. Findings are reported under the following main headings: Literature Related to Measurement, Literature Related to Place Value/Regrouping, A Review of the National Mathematics Assessment, and Literature Related to Student-Centered Writing.

Literature Related to Measurement

Measurement has roots that probably extend to primitive man. Undoubtedly, early man compared sizes of objects, distances, time and temperatures. Depending on perception, the crude measurements took on different meanings; "far" to one man in search of food might have seemed "close" to another hiding from an enemy. Evolvement of a system of more precise measurements may have stemmed from a need to communicate more accurately.
Only speculation can be made about what system of measurement was the earliest to be developed. However, it seems only natural that early man used a system that needed little thought, was readily available and was easy to transport on his person. Body parts provided such a system. The width of a finger, length of a stride and size of a foot were as natural as counting using fingers as markers.

Historical evidence from early civilizations revealed the use of body parts in measurement systems (Heddens, 1980). Egyptians and Babylonians used the length of the forearm as a common measure called the cubit. Ancient Romans, ancient Greeks and medieval Europeans also used the cubit as well as other body part measures such as the width of the index finger, called a digit, the width of the hand and the length of the foot.

Limitations of early measurement systems, due to variations of body parts from one individual to another, led to a system of standard measures with units that were the same for all people (Heddens, 1980). Leaders of various nations decreed national units of measure which facilitated communication within a country. However, as communication and trade increased between nations, a need was created for international standard units of measure. International bureaus of standards were established in the nineteenth century to define each country's units of linear measurement, weight, time and volume. In the twentieth century, these international bureaus of standards finally adopted the metric system as the universal standard system of measurement.

Just when measurement became a part of the mathematics curriculum
has not been determined. Heddens (1980) concluded that students in ancient Greece studied measurement in the discipline of geometry, since the term "geometry" has a Greek derivative meaning "earth measure". Once only a part of the secondary school curriculum, today geometry has permeated the elementary school mathematics curriculum as well.

While most authorities included measurement as a mathematical topic of study, not all were in total agreement regarding the mathematical definition of measurement. Swain and Nichols (1965) defined measurement as a physical activity. They argued that the computations involving the results of measurement are mathematical. Williams and Shuard (1971) agreed that measurement begins with physical activity, but defined it as a process of assigning number to attributes of an object. Osborne (1976) defined measurement as a process and a skill using devices to assign number. Lerch (1981) argued convincingly that measurement is the process of applying the ideas of numeration and notation. He included counting, combining, separating, estimating and comparing as components of the measurement process.

Others have attempted to classify two kinds of measurement. Direct measurement was identified as the direct comparison of one object's quantity with another object, such as using a ruler (Steffe and Hirstein, 1976; Heddens, 1980). Indirect measurement was identified as the perception of a quantity that can't be directly compared with another object, such as time. Ashlock et al. (1983) provided a slight variation to the dual-classification by identifying discrete measurement as units that can be counted directly, and continuous measurement as units that cannot be counted directly.
Teaching measurement as a unit of study in primary school mathematics has centered on the practical use of measurement in everyday life (Gibb and Castaneda, 1975; Sanders, 1976; Ashlock, 1983). Its real-life use provided the basis for goal-setting and for recommending an activity approach for teaching measurement.

An activity approach represented a change in instructional philosophy. For years, instruction in measurement in primary school emphasized the mechanical process using standard unit measuring devices. Findings by Piaget (1965) influenced the philosophical change. His inclusion of primary students in the pre-operational stage of development until age eight resulted in the increased use of manipulatives in activities designed to develop conceptual understandings. Inskeep (1976) concluded that activities using manipulatives give meaning to measurement. In a recent study of first and second grade students, the use of manipulatives was found to be more effective than the use of graphics in learning linear measurement skills (Smith et al., 1980).

Gibb and Castaneda (1975) established a sequence for activities to be used for teaching measurement. The activity sequence recommended using general concept-building activities first, followed by activities designed to develop concepts of non-standard units, activities to develop concepts of standard units, and finally activities involving actual standard unit measuring devices. Teaching measurement in this sequence will enhance students’ discovery of the need for standard units of measure (Paige et al., 1982).

Studies have shown that primary students already have experienced
some measurement activities prior to entering school. Rea and Reys (1971) concluded that more than one-half of the kindergarten students they tested could identify the use of several measurement devices. In another study, first grade students were found to be quite familiar with measurement (Mascho, 1961). Of course, such studies were limited to the time and place of the study, but the results indicate that primary students have some measurement experience before entering school.

Teaching measurement presented moments of frustration for teachers and their students for years (Robinson et al., 1975). Many authorities have responded with lists of recommended activities and materials for teaching measurement (May, 1970; Rosskopf, 1972; Pottinger, 1975; Robinson et al., 1975; Inskeep, 1976; Jackson and Prigge, 1976; Ashlock et al., 1983). Measurement activities involving play and discovery included the use of materials such as geoboards, attribute blocks, Cuisenaire rods, sticks, clocks, as well as metric and English rulers, yardsticks, metric sticks, weight scales, liquid containers and other standard unit measuring devices.

Elementary teachers contemplated several issues related to teaching measurement to primary grade level students. On the issue of whether to teach measurement skills or concepts, Lerch (1981) and Shepherd and Ragan (1982) advised teachers to emphasize both beginning in kindergarten and extending throughout elementary school. Lerch further advised teachers to teach a unit on measurement and not to teach only incidental measurement lessons on special occasions.
Regarding how much emphasis a teacher should place on precision, the recommendation was to start with very little precision by teaching estimation and to develop a transition to more and more precise measurements as students increase in grade level (Bright, 1976; Lerch, 1981; Copeland, 1982; Paige et al., 1982). It was generally noted that students must learn that no measurement is exact, regardless of the attempt for precision (Osborne, 1976).

Lerch (1981) recommended a spiral development of measurement concepts beginning with conservation, which is knowing that the quantity does not change simply because of a change in the shape or configuration of that quantity. Transitivity, being able to transfer knowledge of one object in comparison of two other objects, was also noted as a concept that primary grade level students must develop.

Piaget's studies of conservation and transitivity exerted a tremendous influence on mathematical measurement as a component of the primary school curriculum. Many mathematics educators advocated his findings as a philosophical foundation for teaching measurement (Lovell, 1971; Inskeep, 1976; Copeland, 1982; Shepherd and Ragan, 1982; Ashlock et al., 1983). Based on Piaget's findings regarding transitivity, Steffe and Hirstein (1976) concluded that primary grade level students need to develop transitivity prior to being taught measurement, although they admitted to contradictory findings. Also using Piaget's findings, Copeland (1982) questioned whether or not first, second and third grade students should be taught measurement. However, most other authorities advocated measurement activities to be used with primary grade students for the development of conceptual
understandings of conservation and transitivity, which they believed to be a prerequisite for other measurement conceptual understandings.

While most agree with the theoretical base Piaget's research has established for measurement, some authorities recommended caution. Gelman (1969) conducted a study on conservation acquisition and reported that primary grade level students are not inadequate in their thinking development, as Piaget (1965) suggested. She concluded that the students are only inadequate in their attending and can be taught to attend to relevant attributes such that their conservation scores increase significantly. Stevenson (1975) also found young children to be distracted by irrelevant information and cautioned against complete acceptance of Piaget's findings. Taloumis (1975) questioned Piaget's conclusion that a young child's ability to measure quantities depends on his ability to conserve. In presenting both to primary grade level students, Taloumis found successful results were obtained whichever sequence was used. Other authorities, such as Sawada and Nelson (1967) reported findings that indicate the ages identified by Piaget for most children's stages of development may be about two years too high.

Although the emphasis changed in how measurement should be taught in primary school following Piaget's research, the content has changed very little during the past few years. In 1926, the State Department of Public Instruction in Montana wrote the State Course of Study which contained recommendations for teaching all subject areas. In mathematical measurement, the recommendation was to teach length, capacity, time, area and money. A summary of the measurement content of thirty-nine textbook series by Paige and Jennings (1967) included
the same topics of study, adding only the topic of metrics. Shepherd and Ragan (1982) referred to metrics and geometry as the only new topics of study in measurement for elementary school children.

Teaching primary grade level students attributes of objects was a content topic recommended to teach measurement readiness skills (Lerch, 1981; Paige et al., 1982; Ashlock et al., 1983). Comparing attributes of two objects, such as their color, shape, and thickness prepared students for non-standard measurement involving number. Such experiences without number were called premeasurement activities (Reys et al., 1984).

The measurement topics predominantly mentioned as most appropriate for primary grade level students included length, volume/capacity, and time (Lerch, 1981; Paige et al., 1982; Ashlock et al., 1983; Reys et al., 1984). Even with these topics students have been confused. Linear measurement has confused primary students when reference is made to the abstract concept of distance, as does time measurement when reference is made to the abstract concept of a duration of time (May, 1970; Williams and Shuard, 1971). Money, weight/mass and temperature were identified as appropriate measurement topics for primary students by some but not all authorities.

The metric system was strongly recommended as a measurement topic to begin teaching in primary school (Ward and Hardgrove, 1964; May, 1970; Pottinger, 1975; Sawada and Sigurdson, 1976). In addition to being a universal system of measurement for international trade, advantages have been noted due to its base ten structure as compared to the more haphazard structure of the English measurement system.
However, while both systems were deemed worthy to teach while we are in this transition period of converting to metrics, students have been confused when asked to convert between the English and metric measurement systems (Graham, 1979; Paige et al., 1982). Teachers, especially at the primary grade levels, were cautioned to avoid conversions.

Measurement has been said to provide a convenient transition for students about to learn regrouping (Heddens, 1980). For example, if a student calculated measurements and obtained a measure of nine inches and another of five inches, he could combine the measurements to get fourteen inches. Instruction could be provided to teach the student that fourteen inches can be regrouped into one foot and two inches.

Teaching the history of the English and metric systems of measurement interested students and can be taught as a measurement topic in third grade (Copeland, 1982). In addition to its motivational value, when the students have "relived" measurement history by inventing their own units of measure, using body parts as units of measure and developing the reasons behind standardization of units of measure, they have developed better conceptual understandings of measurement.

Kerr and Lester (1976) developed a four-step model for teachers to analyze the measurement errors of their students. First, teachers were advised to examine the assumptions made about the object being measured. Second, teachers were to examine which measurement instrument was chosen by each student and then examine how it was used. Finally, teachers were to examine any calculations that had been made
from the measurements. A further recommendation was for teachers to use their findings in teaching students how to prevent common errors.

Due to the everyday use of measurement, it has been integrated with other subject area (May, 1970; Lerch, 1981; Reys, 1984). Language arts was specifically mentioned as an ideal area to integrate with measurement.

Several authorities emphasized that teachers utilize the communication skills of primary grade level students to develop a conceptual understanding of measurement. Lerch (1981) called for teachers to teach measurement vocabulary, not through memorization, but by reading and writing measurement terms in context. Shepherd and Ragan (1982) also emphasized the need for students to develop measurement comprehension by reading and writing, or measurement will be reduced to a system of nonsense symbols. Reys (1984) referred to mathematics as a language, thus emphasizing to teachers the need to teach the language of measurement.

In spite of the strong recommendations for primary teachers to utilize reading and writing as an integral part of measurement instruction, no evidence existed that demonstrated it was being done. Perhaps it was because no studies were found to determine the effect such instruction would have on student achievement for measurement, or that no studies were found to determine which, if any, method of student-centered writing would be most effective in teaching mathematical measurement.
The historical origin of place value/regrouping was somewhat elusive. Surely, its roots were tied to counting which early man probably accomplished by using markers such as his fingers. Counting may have been a system of grouping objects by ones, or even tens, for a period of time until the development of numerals. Numerals allowed for groups of ones to be "traded" for tens, and groups of ten to be "traded" for hundreds, and so forth. Each trade required the assignment of a numeral, which thereafter held a place for its value. This trading, or grouping and regrouping objects, may have been the origin for the abstract concept used in the algorithms of addition and subtraction with regrouping.

When the regrouping process using objects evolved to the abstract algorithm process, it may not have begun as a left-to-right process as we know it today. The Hindu addition algorithm with regrouping was a right-to-left process (Swain and Nichols, 1965). Computing in dust, erasing was easy, and an addition exercise may have been as follows:

\[
\begin{array}{cccc}
5547 & 5547 & 5547 & 5547 \\
+ 394 & + 394 & + 394 & + 394 \\
\hline
58 & 593 & 593 & 5941
\end{array}
\]

The Europeans, with no system for quick erasing, modified the Hindu algorithm into a scratch method. The same exercise using the European scratch method for addition may have been as follows:

\[
\begin{array}{cccc}
5547 & 5547 \\
+ 394 & + 394 \\
\hline
5941
\end{array}
\]
Eventually, perhaps to save space used by scratching and rewriting, the process was further modified to a right-to-left process.

Place value/regrouping, hereafter referred to as regrouping, was defined as "the process of changing a number of one place value into a number of another place value, holding the value of the number constant" (Heddens, 1980:139). For example, two tens could be regrouped to become twenty ones; twenty ones could be regrouped to become two tens. This concept was essential for an understanding of why the right-to-left process of regrouping is successful.

The literature contained references to the regrouping process that used the term "regrouping" and/or the term "renaming". "Regrouping", the more common term used, was the only one used by some authors (Brownell, 1949; Swain and Nichols, 1965; Hicks et al., 1970; Williams and Shuard, 1971; Cacha, 1975; Sherrill, 1979; Heddens, 1980; Ashlock et al., 1983). Other authors chose to use only the term "renaming" (Ward and Hardgrove, 1964; May, 1970; Smith, 1973; Wiles et al., 1973; Graham, 1979; Copeland, 1982). Whereas Adams et al. (1977) used both terms, they drew a literal distinction between the two terms in pointing out that only concrete objects can be regrouped and only numerals can be renamed. Lerch (1981), Paige et al. (1982) and Keys et al. (1984) chose to use both terms somewhat synonymously without making such a literal distinction.

Two other terms referring to the regrouping process were found in the literature. "Carrying" was a term often associated with regrouping in addition, and "borrowing" was often used for regrouping in subtraction (State Department of Public Instruction, 1926; May, 1970;
Graham, 1979; Reys et al., 1984). However, objections to the use of those terms were found (Ward and Hardgrove, 1964; Copeland, 1982; Ashlock et al., 1983). Most authors refrained from using either term.

Elementary teachers have had the goal of helping their students move from the real world of concrete objects to the abstract world of number (Folsom, 1975). In doing so, they have also had the goal of helping their students assign meaning to number (Hicks et al., 1970). These goals have been especially pertinent as elementary teachers have taught regrouping to primary students.

Prerequisite skills should be identified for primary students before they are introduced to regrouping in addition and subtraction. An obvious prerequisite to regrouping has been the ability to count (Williams and Shuard, 1971; Hicks et al., 1970). Ashlock et al. (1983) listed the ability to count up to one hundred and being able to group objects into tens as essential to developing a conceptual understanding of the regrouping process. Primary students must also have an understanding of place value and be able to rewrite numbers in expanded form as prerequisites to regrouping (Lovell, 1971; Heddens, 1980; Lerch, 1981; Hicks et al., 1970). In a study of students in grades four through seven, Flournoy et al. (1963) found that items missed frequently by students reflected a deficiency in one or more of these prerequisites.

Although the ability to add and subtract was generally understood to be a prerequisite to regrouping throughout the literature, Reys et al. (1984) proposed the introduction of regrouping before either addition or subtraction without regrouping were taught. The basis
behind the unique proposal was to help students develop a meaningful concept of regrouping, rather than just a mechanical understanding. No research to verify or dispute this proposal was found in the literature.

Once students have mastered the prerequisite skills, addition with regrouping has usually been introduced before subtraction with regrouping. In a study of second grade students, Wiles et al. (1973) reported the highest achievement results when addition with regrouping was introduced before subtraction with regrouping, as opposed to a subtraction-first method or a simultaneous method.

A comparison of a recommended sequence for teaching regrouping to primary grade level students in 1926 with a similar recommendation in 1970 revealed very few differences. The State Department of Public Instruction (1926) of Montana recommended teaching regrouping for addition and subtraction in the third year of school, which would be comparable to second grade in a school with a kindergarten. Hicks et al. (1970) recommended only teaching regrouping in addition and subtraction to tens in the second grade, followed by teaching multi-digit addition and subtraction with regrouping in the third grade.

The only method for teaching addition with regrouping to primary grade level students was by regrouping sets of ten. Teachers decided whether to teach it meaningfully with an understanding for the process of regrouping, or to teach it mechanically as simply an algorithm. However, there were two major methods for teaching subtraction with regrouping. While still having to decide whether to teach regrouping
meaningfully or mechanically, primary school teachers have been able to choose between the "decomposition" method and the "equal addends" method when teaching subtraction.

The decomposition method of regrouping in subtraction has been explained with problems similar to the following:

\[
\begin{align*}
63 & \rightarrow 6 \text{ tens } 3 \text{ ones } \rightarrow 5 \text{ tens } 13 \text{ ones (renamed)} \\
-47 & \rightarrow -4 \text{ tens } 7 \text{ ones } \rightarrow -4 \text{ tens } 7 \text{ ones} \\
& \hspace{1cm} \frac{1 \text{ ten}}{\underline{6 \text{ ones}}} \rightarrow \underline{16}
\end{align*}
\]

Based on the understanding that "1 ten = 10 ones", the equal addends method has been explained as follows:

\[
\begin{align*}
63 & \rightarrow 6 \text{ tens } 3 \text{ ones } \rightarrow 6 \text{ tens } 13 \text{ ones (added 10 ones)} \\
-47 & \rightarrow -4 \text{ tens } 7 \text{ ones } \rightarrow -5 \text{ tens } 7 \text{ ones (added 1 ten)} \\
& \hspace{1cm} \frac{1 \text{ ten}}{\underline{6 \text{ ones}}} \rightarrow \underline{16}
\end{align*}
\]

In a study of 1400 third grade students, Brownell (1949) tested both the decomposition method and the equal addends method. In addition, he tested each method using a meaningful approach and a mechanical approach. From the results, Brownell concluded that the decomposition method using a meaningful approach was the best combination to achieve the highest understanding and accuracy.

In a follow up study on third grade students, Sherrill's (1979) findings supported Brownell's conclusions. The decomposition method proved superior to the equal addends method for highest accuracy.

Paige et al. (1982) suggested that teaching either method is fine if only one method is taught to the students. Reys et al. (1984) tended to agree, pointing out that both methods are effective for speed and accuracy if taught with a meaningful emphasis as opposed to a mechanical emphasis.

In England, Williams and Shuard (1971) suggested that the
decomposition method of teaching subtraction with regrouping is easier than the equal addends method. They indicated that the adding of ten to both addends may result in the increased difficulty of the equal addends method. Interestingly, Ashlock et al. (1983) recommended the decomposition method based on previous research, while noting that the equal addends method commonly used in Europe has been found to be faster but more difficult to understand conceptually.

Overall, the literature review revealed general agreement that the decomposition method was best to use to teach subtraction with regrouping, but it also revealed an overall agreement that primary grade level students have had difficulty trying to learn regrouping in subtraction (Smith, 1973; Wiles, 1973; Sherrill, 1979; Heddens, 1980; Ashlock et al., 1983; Ewbank, 1984). In spite of the research and attempts to use different methods to teach subtraction with regrouping, the problem of difficulty for students has apparently not been arrested.

Other suggestions have been made for facilitating student understanding of regrouping in addition and subtraction. The use of manipulatives was a common recommendation (Williams and Shuard, 1971; Lovell, 1971; Lerch, 1981; Ashlock et al., 1983; Reys et al., 1984). The State Department of Education (1926) of Montana urged teachers to use dimes and pennies to develop an understanding of regrouping. Copeland (1982) also recommended the use of dimes and pennies to introduce regrouping and then Diene's blocks to develop a more comprehensive understanding. Paige et al. (1982) recommended the use of popsicle sticks and Cuisenaire rods.
Measurement has provided a transition to facilitate the understanding of regrouping (Montana Department of Public Instruction, 1926; Williams and Shuard, 1971; Heddens, 1980). Primary students have regrouped inches to feet, feet to yards, ounces to pounds, centimeters to meters, and so forth. Addition and subtraction with such regroupings have been accomplished to help explain the regrouping process. For example, 6 feet and 5 inches added to 3 feet and 9 inches resulted in 9 feet and 14 inches, which in turn can be regrouped to equal 10 feet and 2 inches. Using the same example for subtraction, 6 feet and 5 inches can be regrouped to become 5 feet and 17 inches to enable the subtraction of 3 feet and 9 inches, resulting in 2 feet and 8 inches as the answer.

Learning the conceptual understanding of regrouping in addition and subtraction necessitated that primary students think. They need a balance between the development of mathematics concepts and skills and the development of thinking skills (Trafton, 1971). This balance has been accomplished by teachers who have been able to determine the students' thinking that led to both correct and incorrect answers. Ginsburg (1977) argued convincingly that effective instruction in mathematics should be based on the student's misconceptions, which teachers need to determine. In a study of first grade students, Leutzinger (1980) found that teaching mathematics with appropriate thinking strategies facilitated learning.

In studies of young children, Graves (1975) concluded that writing facilitated learning. The writing process and the thinking process are interwoven, each facilitating the development of the other.
Also, the written thoughts of primary students enabled teachers to quickly assess misconceptions.

Primary grade level students search for meaning in their thinking strategies, and often invent rules to make sense out of a new concept (Ashlock et al., 1983). Correction of their error in thinking has been the key to reteaching. Ashlock et al. (1983:7) tell the story of the child who was confused on which side of the computation problem to begin, until the teacher clarified things with directions to begin on the piano side. The student was successful at computation the rest of the year. However, the next year the student missed the majority of the computation problems. Reteaching was only successful when the thinking of the child was determined; the piano was on the opposite side of the new room. Ashlock et al. used this story to emphasize the need for teachers to observe students closely in an effort to determine the thinking strategies leading to errors.

Student-centered writing was recommended by Graves (1978) as a method that teachers have used in the intermediate grades and beyond to observe the thinking strategies of their students. Also, student-centered writing was recommended to assist students in thinking about difficult concepts. However, no evidence existed in the literature review of any study utilizing a method such as student-centered writing to determine regrouping misconceptions of primary students, nor to determine possible effects on mathematics achievement.
A Review of the National Mathematics Assessment

General Information

The National Assessment of Educational Progress (NAEP) conceived in 1964 involved all fifty states in the assessment of ten subject-matter areas, one of which was mathematics (Foreman and Mehrens, 1971). Assessment in mathematics was originally scheduled to be accomplished in 1972-73 and 1977-78, although a third assessment was done in 1981-82. Funding for the development of this extensive project was from the Carnegie Corporation and shifted in the implementation phase to the United States Office of Education.

The goals of the mathematics assessment were to determine the mathematical attainments of young Americans, ages 9, 13, 17, and 26-35, to report these findings nationally and to periodically assess progress in this area. The mathematics objectives originally were classified as "content" and "behavior" objectives, and the third classification, "uses of mathematics", was added prior to administering the first assessment. Fifteen of the sixteen subcategories of the content objectives were administered to the 9-year-olds; trigonometry and parts of other subcategories not appropriate for primary students were omitted (Foreman and Mehrens, 1971).

A research study was conducted prior to administering the assessment to determine if a significant difference in scores resulted between formal and informal language used on test questions. No significant difference was found (Foreman and Mehrens, 1971).
In addition to the age levels previously mentioned, other data variables collected and reported were sex, geographic region, level of parental education, size and type of community and race (Martin and Wilson, 1971). For the purpose of this study, concern was centered on the mathematics assessment results of 9-year-olds since they would either be in or just completed primary school. Also, concern was centered on the results related to the two topics of this study, measurement and place value/regrouping.

The First National Mathematics Assessment

The first NAEP of mathematics was administered in 1972-73. Major findings were reported in the Arithmetic Teacher (Carpenter et al., 1975a). Although some people felt that the modern math programs of the previous decade had destroyed elementary students' mathematics skills, the first NAEP did not confirm their theories.

Results revealed that primary students had developed a good foundation of numeration and place-value concepts (Carpenter et al., 1975a). Nearly all students could count by 10s, read a four-digit number, name the number in the tens place and write a three-digit number expressed in words. Only thirteen percent of the students could not select the greater of 3000 and 3200.

Primary students did well on place value concepts but did not do so well on computation exercises involving place value/regrouping. For example, when adding 38 and 19, only seventy-nine percent responded correctly. It was reported that six percent made errors in regrouping.
and fifteen percent made other types of errors (Carpenter et al., 1975a). Subtraction results involving place value/regrouping were far worse. Only fifty-five percent responded correctly when asked to subtract 19 from 36. Although only 3 percent actually made regrouping errors, eighteen percent made reversal errors, always subtracting the smaller digit from the larger digit in each column. The indication was that primary students have not acquired a conceptual understanding for addition and subtraction when place value/regrouping is necessary.

The results of word problems by primary students also demonstrated their lack of a conceptual understanding of place value/regrouping in addition and subtraction. For example, in a word problem requiring subtraction with regrouping, seventy-nine percent of the primary students answered it incorrectly, with 14 demonstrating reversal errors. Although Carpenter et al. (1975a) acknowledged the difficulty word problems have always presented to students, they concluded that simple word problems have been solved correctly when the students had an understanding of the related mathematical concepts.

Carpenter et al. (1975b) made an interesting observation of the students' responses on exercises involving subtraction with regrouping. They found that primary students scored poorly having just received instruction on regrouping, but that 13-year-olds with far less recent instruction scored much better, and that 17-year-olds with no recent instruction scored even better yet. Therefore, although primary students tended to rely on the rote use of the algorithm, a conceptual understanding of regrouping may have developed some time after the actual instruction.
conversion exercise involving the conversion of inches to feet, with similar results on conversions such as pints and quarts.

Primary students demonstrated the lack of a conceptual understanding of linear measurements (Carpenter, 1975b). They could do linear measurements, but most could not measure lengths longer than the ruler. Also, most could not measure lengths that involved fractions other than one-half, most could not make indirect measurements, and most could not estimate lengths. When asked to respond to exercises in which they had to complete calculations involving several measurements, such as the distance around a rectangular object, only seven percent could do it successfully. A deeper look into student responses on word problems involving perimeter, area and volume, lead Carpenter et al. (1975b) to conclude that primary students did not conceptualize the measurements involved, but instead applied rote calculations using all the numbers given in the problem.

Measurement exercises involving the concept of time revealed similar results (Carpenter et al., 1975a). When hour intervals were presented, over ninety percent of the primary students could read the clocks. Eighty-percent could read clocks with half-hour intervals, and seventy-three percent could read clocks with five-minute intervals. However, when primary students were asked to calculate the number of minutes between two given times, results indicated that only twenty-five percent had a conceptual understanding of time.

In summary, the first NAEP of mathematics appeared to reveal that primary students lacked a conceptual understanding of measurement. Likewise, they did not seem to understand the concept of place
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Primary students demonstrated the lack of a conceptual understanding of linear measurements (Carpenter, 1975b). They could do linear measurements, but most could not measure lengths longer than the ruler. Also, most could not measure lengths that involved fractions other than one-half, most could not make indirect measurements, and most could not estimate lengths. When asked to respond to exercises in which they had to complete calculations involving several measurements, such as the distance around a rectangular object, only seven percent could do it successfully. A deeper look into student responses on word problems involving perimeter, area and volume, lead Carpenter et al. (1975b) to conclude that primary students did not conceptualize the measurements involved, but instead applied rote calculations using all the numbers given in the problem.

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In summary, the first NAEP of mathematics appeared to reveal that primary students lacked a conceptual understanding of measurement. Likewise, they did not seem to understand the concept of place
value/regrouping during addition and subtraction with females attempting and showing a slightly better understanding of regrouping than males. Although the understanding of concepts was lacking, primary students did demonstrate a mechanical competency in the basic skills of measurement, place value and computation.

The Second National Mathematics Assessment

The second NAEP assessment of mathematics was conducted in 1978-79. Since these results followed six years after the first NAEP, a basis for comparison existed between the two. Findings relevant to elementary students were reported in the Arithmetic Teacher.

Like the first NAEP, the results of the second revealed that primary students performed well on numeration and place value exercises. A comparison of the results from both assessments indicated very little change (Carpenter et al., 1980). Once again, primary students showed a definite weakness in conceptual understandings during addition and subtraction involving place value/regrouping. A similar weakness was demonstrated when students completed measurement exercises.

The correct responses declined from seventy-five percent on the first NAEP to fifty percent on the second NAEP when students were asked to name the digit in the tens place. However, when students on the second NAEP were asked to tell the value of a given digit in the tens place, nearly eighty-four percent responded correctly. Therefore, it was concluded by
Carpenter et al. (1980) that students who can state the digit given the place can not automatically state the value given the digit.

Rathmell (1980) studied the results of the second NAEP with specific concern for students' performance on the fundamental operations. From the results of exercises requiring students to apply the number line model to addition and subtraction, he concluded that primary students did not understand this model well enough for such a purpose. Furthermore, he noted the decline in scores for problem-solving involving just the fundamental operations since the first NAEP, thus lending additional evidence that students were operating on a mechanical level and not on a conceptual level.

The scores of students on addition problems requiring regrouping were nearly identical on both the first and second NAEP. About seventy-nine percent of the students on the second NAEP responded correctly on addition exercises requiring regrouping, with a sharp decline to fifty percent when addition with regrouping involved four-digit exercises.

The performance of primary students on subtraction requiring regrouping was better on the second NAEP than on the first. Correct responses increased from fifty-five percent to sixty-five percent, although zeros in subtraction continued to present a problem to students. On both assessments, reversal errors contributed to a greater percentage of subtraction errors than did regrouping. The high percentage of reversal errors, with very few attempts at regrouping, indicated that students were using a rote manipulation method of subtraction with very little conceptual understanding of place.
Some changes were noted for primary students on the topic of measurement when the results of the two assessments were compared. For example, students demonstrated a much higher familiarity with the metric system on the second NAEP than on the first. Yet, the students' responses indicated a decline of about three percent on conversion problems involving the English system of measurement, with a similar decline on problems involving units of time (Carpenter et al., 1980). Therefore, the increase in familiarity with metric units did not result in an increase in conceptual understandings of measurement.

Students' responses on the first and the second NAEPs in mathematics indicated that students can perform well on simple linear measurement skills. On the second NAEP, eighty-one percent of the primary students responded correctly when asked to measure a line segment, even though it was longer than the ruler at times. This increase from the first assessment was similar to the increase in students' performance on measuring distances around geometric shapes and in telling time (Carpenter et al., 1980). However, Hiebert (1981) argued convincingly that an analysis of the results of the second NAEP showed that students maintained a lack of conceptual understandings of measurement.

Carpenter et al. (1980) reported positive affective responses of students toward mathematics as evidenced by the second NAEP results. While noting caution about affective measures where a self-reporting method is employed, they indicated that sixty-five percent of the primary students liked mathematics with only eleven percent expressing
a dislike. Sixty-one percent expressed a preference for doing mathematics problems at the board, fifty-four percent for using a mathematics textbook and only twenty percent for doing mathematics homework. Writing about mathematics, such as journal writing or creating word problems, was not listed as a student-centered activity that was measured for affective responses. No mathematical topics were disliked by primary students. Measurement received a fifty-nine percent favorable response, and sixty-one percent of the students indicated that it was easy. Sixty-five percent of the students liked addition and said it was easy, compared to only forty-seven percent that liked subtraction and fifty-nine percent who said it was easy. Carpenter et al. (1980) concluded that students liked mathematics, but saw their role in mathematics as passive and the teacher's role as active.

Two exercises on the second NAEP were used to determine how students perceived mathematics according to gender differences (Carpenter et al., 1980). Sixty-five percent of primary males and sixty-six percent of primary females disagreed that mathematics is more for boys than for girls, although twenty-one percent of the boys agreed compared to only ten percent of the girls. When asked to respond to the inverse statement, that mathematics is more for girls than for boys, the students responded with nearly the same percentages.

In summary, primary students liked mathematics. They performed well on mathematical knowledge and skills on the second NAEP, but lacked conceptual understandings of place value/regrouping and measurement. In fact, correct responses on word problems involving
these concepts declined, which provided additional evidence that students were learning on a rote manipulation level rather than a conceptual level (Carpenter et al., 1980).

The Third National Mathematics Assessment

The third NAEP for mathematics was administered in 1982. Of greatest significance, when these results were compared with those of the first and the second NAEP, was that very little change has occurred in student performance, especially in gaining conceptual understandings in mathematics (Linquist et al., 1983). Although the overall performance of primary students showed little change, some changes were reported.

Once again, primary students demonstrated a high performance level on basic numeration and place value concepts (Lindquist et al., 1983). However, when asked for a deeper understanding, such as identifying the number that is represented by seven tens, the correct responses declined from eighty percent on the second assessment to seventy-three percent on the third assessment. A similar decrease, 10 percent, was found when students were asked to subtract two three-digit numbers involving regrouping; less than half of the students on the third assessment could set up the problem compared with two-thirds who knew how on the second assessment.

In contrast, primary students performed slightly higher on measurement during the third assessment than they did on the second (Lindquist et al., 1983). The familiarity with the metric system
continued to increase, with a corresponding decrease in performance using the English system of measure. Performance increased on basic skills, such as measuring with a ruler, recognizing standard units of measure and telling time. However, as on the first and second assessments, the third assessment revealed that primary students still were not developing conceptual understandings in measurement.

The third assessment revealed an approximate increase of ten percent in primary students' responses that they felt mathematics was easy, compared to the second assessment (Lindquist et al., 1983). There was only a two percent increase in responses that measurement was easy, but as much as ten percent increase in responses that addition and word problems were easy. Other affective measures resulted in the same responses as the second assessment.

Other overall comparisons were reported between the third assessment and the second assessment (Lindquist et al., 1983). Significant increases in performance of minority students occurred on the third assessment. As on the past two assessments, gender differences resulted in a small difference in performance and attitude for primary students.

For primary students, very little differences occurred among the results of the three NAEP assessments from 1972 to 1981. The overall indication was that primary students tended to operate on a rote manipulation level with little conceptual understandings in mathematics.
Literature Related to Student-Centered Writing

Writing As Thinking

Writing in American schools has traditionally been a major part of the curriculum as one of the basic three Rs that every child had to learn. Teaching of writing included instruction in handwriting, spelling and syntax (Rubin, 1980). It was a method that allowed students to see their language in print; it was a teacher-centered product, not a student-centered process.

As a product, teacher-centered writing served many useful purposes for the students and their teacher. Since early educational practices depended on oral recitation, writing provided a method of written recitation for student responses, thus reducing the strain on student vocal cords, and on teachers' ears. It also provided a record of student responses that assisted students to review information and provided the teacher with a product for evaluation purposes, although this lead to the dreaded chore of reading and marking written work. Writing, generally controlled by and directed to the teacher, took the form of assignments, letters, reports, tests and so forth.

Emphasis slowly shifted from writing as a teacher-centered product to writing as a student-centered process. Piaget (1926) produced the spark for this shift in emphasis to writing as a process; he concluded that children use language to aid their thinking, as well as to communicate. He observed children talking to themselves as they reasoned through a task. Also, children were motivated when they perceived there was an audience, even though the audience oftentimes
was just an illusion of being heard and understood. Piaget’s conclusion, that children use language as a process to motivate and develop their thinking, formed the basis for the premise that writing is a process that facilitates thinking. However, Piaget’s spark lay dormant for several years, failing to kindle a flame.

Vygotsky (1962), a noted Russian psychologist and educator, developed similar conclusions as Piaget about the same time, but the translation caused a delay. Vygotsky’s conclusion was that writing provided a control for one’s thinking. He viewed writing as a cultural tool that took place in social settings. As such, he proposed that writing allowed people to control their ideas as they were being formed. Language served as a stimulant to thinking and as a means to organize thinking, thus providing a link in developing higher level psychological processes. In *Mind and Society*, Vygotsky (1978) said:

> The most significant moment in the course of intellectual development which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously completely independent lines of development, converge (p. 24).

Perhaps it was Britton (1970) in England who finally added the fuel to kindle the fire when he reviewed the writings of Piaget and Vygotsky. Britton explored writing as a product versus writing as a process. He found that writing was considered a product early in primary school, as evidenced by students copying the teacher’s product and then proudly displaying their possessions on the walls. Little thinking was required or stimulated as the teacher clearly controlled the writing. Britton referred to a report on elementary schools in
England that forbade teachers to allow students to express themselves and, instead, called for increased imitation of the teacher; ironically, the report was published in 1925 at the very time that Piaget and Vygotsky were writing about their findings.

Britton concluded that writing had to be more student-centered. Writing was necessary for students to express their thoughts and to use in the development of their thoughts. He equated student-centered writing with an artwork expressing ideas that the artist has not conceived until the artwork displayed them to him.

Soon others were exploring the innovative postulate that writing is as much a process as it is a product. Murray (1968) and Holt and Vacca (1981) found that writing was an internal process that allowed ideas to be developed as they were being expressed. Writing was a discovery process that unlocked meaning and provided a tool for communicating that meaning.

Examining the writing processes of seven-year old children, Graves (1975) found that young children used writing to explore their thinking as they wrote. Writing facilitated learning, and learning was observable when a student was able to write about it.

Calkins (1978), viewing writing as a discovery process, also reported that children actually learned by writing. Inner feelings and ideas, unconscious to the child, were revealed by writing. Children considered and reconsidered the content as they wrote, utilizing writing to organize their search for meaning.

Writing was considered by Fulwiler (1982) as an essential element for students to integrate learning. As the connecting device between
students' language and the content, writing allowed students to digest knowledge and gain a fuller understanding.

Intellectual growth depends on writing, proposed Klein (1985). Writing required the thinker to use a high level of abstraction, thereby helping the writer to become a more critical thinker and learner. The thinking process one goes through in writing, Klein argued, is more important than the product of that process.

Piaget (1926) was trying to convince teachers to utilize student-centered writing to develop their thinking. Florio and Clark (1982), however, reported that writing was still a teacher-centered activity. In fact, they reported that writing was actually being restricted by teachers and by commercially-made worksheets. Writing was not being utilized as a student-centered activity to develop thinking. In a case study of a primary classroom, they found that the teacher provided much of the thought and writing on the board, much the way that worksheets provided only limited opportunities for students to write.

In his widely acclaimed book, *Writing: Teachers and Children at Work*, Donald Graves (1983) probably has made an impact on reversing the trend from teacher-centered writing to student-centered writing. Graves developed a conferencing model for encouraging student-centered writing. He called on teachers to organize their classrooms such that writing was encouraged, to write with the children and to interact with children through their writing. While emphasizing that children want to write, Graves indicated that children should have control over what they write as part of the thinking and learning process that writing
enhances.

In a study on sixth grade students, Edelsky and Smith (1984) compared student-centered writing with teacher-centered writing. They found that teacher-centered writing motivated the children to search for the "right" way, how it was supposed to look, and produced very similar written products from all the students. In contrast, students were self-motivated for their own personal purposes during student-centered writing, and the writing took on different forms on a more personal level. Thus, when students were allowed some control of the writing process, that control was transferred to a control of their thinking development.

The development of higher order thinking skills by students was the focal point of concern for the recent educational reform movement that swept our country (Langer and Applebee, 1985). In pointing out that writing and thinking go hand in hand, Langer and Applebee called for student-centered writing as the key to accomplishing the goal of the reform movement. They advocated writing in all areas of the curriculum using writing-and-thinking activities, such as notetaking, reporting, journal writing and creative writing.

Journal Writing in Primary School

Chomsky (1971) and Graves (1975, 1978) purported that primary grade level students want to write and can write. When it was first proposed to encourage primary students to write, the proposals were generally connected with statements about reading. In support of the
language experience approach to teaching reading, Chomsky proposed that primary students be taught to write before they are taught to read. In response to the "back-to-basics" movement, Graves (1975) called for teachers to place a major emphasis on writing.

Writing abilities differed between boys and girls in primary school, particularly in first grade students (Graves, 1979). In comparison to girls, boys tended to do more unassigned writing, tended to be more concerned with spacing and neatness and tended to write more about distant places than girls. Also, boys had more of a tendency to avoid reference to the first person (I) than did girls. Girls tended to write longer entries, to write more about familiar places, to use more illustrations and to emphasize more feelings than boys.

Hoskisson (1979) and DeFord (1980) found that primary students, like their older counterparts, used writing to assist themselves to think and express their ideas. Writing was a fundamental activity in learning, even when young children learned to read.

Ideas were formulated to incorporate writing and reading for primary students. Rubin (1980) found most writing activities blocked student thinking and proposed the "storymaker" activity as a way to integrate reading and writing while providing for an increase in the interaction between students and their teacher. Rhodes (1981) called for the integration of reading and writing using predictable books in first grade to encourage students to write. Another method, the circle story, was presented to integrate reading and writing for primary students (Simpson, 1981).

Primary students wrote effectively when their writing was
analyzed with a disregard for perfect spelling (Gentry, 1981). When encouraged to write, primary students invented spellings. By the beginning of first grade, primary students generally had reached the phonetic stage of spelling, and their writing could be read. As they completed primary school, most students were found to have made the transition to understanding the concept of correct spelling.

In a case study of a remedial reading student, Smith (1982) chose to disregard perfect spelling in an attempt to encourage writing. She credited the integration of reading and writing with making a significant difference in raising the student's reading level by nearly three grade-levels in the one year period of the study.

A classic longitudinal study of students in grades kindergarten through second was completed by King and Rentel (1982). They found that learning to write could be traced to oral language development. Developmental stages showed up first in oral language and then in students' writing. Their research provided an explanation for results teachers were finding as they worked with their students. For example, Collins (1984) reported that her first grade students could write better when she helped them say their thoughts and ideas before writing them.

In an investigation of writing techniques that worked with first graders, Friedman (1985) found that the best technique was simply having them write each day. While advocating that students have a choice of what to write, she recommended that teachers use the technique of assigning writing about concepts being studied. Another technique which Friedman found to be successful was to involve parents
with their children through interaction about the student's writing.

The student-centered writing technique of journal writing was recommended most often throughout the literature. Journals were found to be even more successful than letters, reports and stories. Journal writing was recommended for all levels of students from kindergarten to college. (e.g., Fulwiler, 1982; Hipple, 1985).

Kindergarten students used journal writing successfully (Hipple, 1985). Language arts skills improved as the development of writing skills was observed. Journals were used as emotional outlets by some students. As interaction involving journals took place between the teacher and each student, students were known better compared with other classes. Students complained when journal writing time was omitted. Children invented spellings of words such that the words could be read and their thoughts and meanings communicated.

Klein (1985) also reported that journal writing was appropriate for students in kindergarten. He reported that journals are motivational and should be written in daily by students in primary school. His recommendations urged journal writing throughout elementary school.

Milz (1980) found journal writing to be successful in first grade. First graders used journals effectively to express their opinions and feelings. Their teachers used the journals as a means to interact with the students and found them useful in quickly assessing when and where students were having difficulty.

Although the use of journal writing by students in grade levels above third grade was not directly pertinent to this study, the
literature was reviewed to gain insights that could apply to journal writing in primary school.

The dialogue journals of sixth graders were studied by Staton (1980). She discovered that the journal entries of students increased in size as the year elapsed. Students asked the teacher questions in their journals, and the teacher answered them each night. This resulted in the teacher knowing each student well and providing insights into personalizing instruction. Some of the effects that Staton reported as a result of journal writing included increases in student writing ability and increases in student motivation for several subjects. She concluded that the teacher needs to model journal writing at the time the students write in their journals.

Some interesting findings from journal writing in high school appeared to be applicable to journal writing in primary school. Watson (1980) indicated that writing should be included in high school mathematics class to develop conceptual understandings and that journals were the ideal vehicle for that purpose. Wotring and Tierney (1982) conducted a study of high school science classes and reported higher retention scores of students in classes where journal writing was used, although no immediate achievement differences were noted.

Journal writing in college produced some findings that also provided insights into journal writing in primary school. Fulwiler (1982) concluded that expressive journal writing in college was more effective when followed by discussions about the student entries, with teachers guiding their students to make connections between their own language and the content language. College students gained a deeper
understanding of the material when they wrote about it in their journals. Sister Theresa Craig, from the University of Alberta, found that journals resulted in a self-discovery process for college students as they wrote and learned more about themselves (Dillon, 1983).

Specific recommendations for journal entries were identified. Prediction and reflection entries were recommended (Hays, 1983; Pradl and Mayher, 1986; Sanders, 1985). Students were asked to predict what a topic was about, how it might be taught and what their feelings might be as they learned it. Reflection entries included a follow-up on their earlier predictions, reasons "why" the predictions came about or did not, and also thoughts regarding journal writing. Process entries, when students were asked to explain the process that was involved in doing a computation problem or solving a word problem, were emphasized (Shaw, 1983; Pradl and Mayher, 1986). Entries that required students to write a summary of what they had just learned were urged (Shaw, 1983; Pradl and Mayher, 1986). Writing their own story problems as journal entries in mathematics was recommended by Shaw (1983). Journal entries allowing students to write their feelings were encouraged, such as expressing when a moment of frustration occurred or perhaps a breakthrough in understanding something (Shaw, 1983; Sanders, 1985). Generally, it was recommended that students spend about five minutes to ten minutes daily writing one of the six types of entries identified above. No specific sequence was recommended for these since they came from different sources. Most sources did agree that teachers should model each of these kinds of journal entries for their students.
Writing In Mathematics

Mathematics has always been recognized as a subject that was
difficult for some students to read due to the abstract concepts and
use of different symbols (Kane et al., 1974; Earle, 1976). Kane
concluded that mastery of mathematics cannot be accomplished without
reading behavior. Therefore, when studies were done to determine if
teaching reading in mathematics had any effect, the outcomes were
highly predictable; teaching reading in mathematics class produced
higher mathematics scores (e.g., Skillman, 1972).

However, mathematics has not been known as a subject in which
students had difficulty writing. Narrative writing in mathematics was
not required; correct answers using numerals were required. The
publishers of the textbooks and worksheets provided all the writing, or
the teacher provided it on the blackboard. For years, students were
only required to remember the mechanical steps in algorithms that
produced the right answers.

During the 1960s the philosophy changed. The modern math program
that enjoyed only a short lifespan was based on a philosophy that
stated that it is important for children to have a conceptual
understanding, rather than a purely mechanical understanding, of
mathematics. Although modern math programs faded away, the philosophy
did not. The mechanical steps were of no use unless the underlying
concepts had been learned (Earle, 1976).

Piaget (1926) reported that conceptual understandings were
connected to thinking, which in turn was connected to language. His
studies lead him to link these to stages of development in children. As children progressed from the sensimotor stage through the preoperational stage to the concrete operational stage, their language developed and facilitated thinking. Using their language skills, thinking skills and concrete referants, students were able to acquire conceptual understandings in mathematics.

Writing was recommended as a means to develop language and thinking skills in mathematics (Earp and Tanner, 1980; Watson, 1980). Burton (1984) found that pupils needed to reflect on mathematics concepts and to express their feelings as they developed understandings or became "stuck". She encouraged students to write about mathematics and discovered that the more personal words students chose, the more likely they were to succeed in the mathematics task.

Both elementary and secondary school teachers were encouraged to utilize writing during mathematics instruction. Johnson (1983) encouraged teachers of secondary mathematics to have their students write about mathematics concepts and to write their own story problems. He argued that writing in mathematics would assist students to organize their thoughts and, therefore, to crystalize concepts in their minds. Kamii (1982) encouraged elementary teachers to use less worksheets and to develop children's thinking skills in mathematics. She suggested that students write about mathematics and that teachers use the writing to interact with students to pinpoint individual misunderstandings. Kamii discerned that the use of writing diagnostically in mathematics provided for efficient and meaningful reteaching.

Writing has been used in some mathematics classes. Shaw (1983)
had her junior high students write daily journals during mathematics instruction. She concluded that writing did help the students develop conceptual understandings and increased retention, but that most of all the student-centered writing helped the teacher. Evans (1984) also used daily journals during mathematics instruction with her fifth grade students. Her study of the class and a control group that did not write during mathematics lacked scientific procedures. However, Evans' findings were interesting. She concluded that students in both groups reached approximately the same achievement level score, but the writing group achieved higher gain scores since their pretests were lower than the non-writing group at the outset.

A review of the literature revealed many authorities calling for increased conceptual understandings in mathematics, indicating that the writing process facilitates thinking and deeper understandings, and verifying that primary grade level students can write. However, no reports were found that applied student-centered writing in mathematics for primary grade level students. The literature appeared to be void of research that entertained such a proposal.
CHAPTER 3

PROCEDURES

Introduction

This was a two-part study. The first part of the study was designed to test the effect of integrating mathematics instruction and journal writing for primary grade students on gain scores in achievement in the mathematical skill area of measurement. The second part of the study was designed to test the effect of integrating mathematics instruction and journal writing for primary grade students on gain scores in achievement in the mathematical skill area of place value/regrouping. Both parts of the study utilized a similar set of procedures using the same population.

The procedures used for conducting this study are outlined under the following categories:

1. Population Description
2. Design of the Study
3. Training Sessions
4. Treatment
5. Test Instruments
6. Collection and Organization of Data
7. Statistical Hypotheses
8. Analysis of Data
Population Description

The population sampled was chosen from the primary students in ten separate classrooms in grades one, two and three of Emerson Elementary School and Irving Elementary School, Bozeman Public School District #7, Bozeman, Montana. Students sampled represented the student population of the Bozeman Public Schools and the socio-economic backgrounds of the general population of the city and rural areas of Bozeman, Montana. Bozeman Public Schools had an approximate enrollment of one thousand four hundred elementary students distributed within five elementary schools and a total enrollment of approximately four thousand students in grades K through 12. These students come from the city of Bozeman with a population of approximately twenty-nine thousand people distributed within a four and one-half mile metropolitan area, and from the surrounding rural area with a population of approximately forty-seven thousand people. The metropolitan area of Bozeman included Montana State University with a population of approximately ten thousand college students. The Bozeman Chamber of Commerce described the socio-economic status of the population as an estimated per household yearly income of eighteen thousand dollars in 1982, an unemployment rate of approximately seven and four-tenths percent in 1982, and employment in farming, manufacturing, utilities, wholesale and retail trades, government, and services.

The two elementary schools in this study, Emerson Elementary School and Irving Elementary School, were chosen due the involvement of their teachers in an inservice project to increase writing of
elementary students. Following a district-wide inservice project, two Montana State University professors initiated a follow-up project to increase student-centered writing in mathematics. One first grade teacher, two second grade teachers and two third grade teachers from these two schools demonstrated an interest in the follow-up project.

Following their agreement to participate in training sessions specifically designed toward journal writing in mathematics in primary school, these five teachers were selected by the researcher to provide instruction to the experimental group in this study. One first grade teacher, two second grade teachers and two third grade teachers were randomly selected from the remaining primary teachers in Emerson Elementary School and Irving Elementary School to provide the instruction to the control group. Random selection of the teachers for the control group students resulted in a balance of five teachers from each elementary school, as well as an equal number from each school representing the experimental and control groups.

Primary students in Emerson Elementary School and Irving Elementary School were assigned to teachers by the respective principals prior to this study, thereby prohibiting a truly randomized sample. Assignments were made by principals based on the criteria of 1) heterogenous classroom populations, 2) a high, middle, and low reading group structure per classroom, 3) an equal number of students per classroom in each grade, and 4) an equal number of males and females per classroom in each grade. Applying these criteria, with criteria 3) and 4) applied more strenuously than the others, the principals randomly assigned students to classrooms. Therefore, a
stratified random sampling process had been utilized, and the assumption of equiprobability was subsequently made by the researcher. As an added precaution, it was decided to utilize the pretests to assess equivalence of groups for each skill area of instruction.

Students in the experimental group received mathematics instruction that included writing in daily math journals; the control group received mathematics instruction with no writing in daily math journals. One first grade classroom, two second grade classrooms, and two third grade classrooms composed each of the two groups. The experimental group included 29 students in first grade, 47 students in second grade, and 54 students in third grade, for a total of 130 students. Of those, 17 boys and 12 girls were in first grade, 23 boys and 24 girls were in second grade, and 27 boys and 27 girls were in third grade, for a total of 67 boys and 63 girls altogether. The control group included 25 students in first grade, 46 students in second grade, and 49 students in third grade, for a total of 120 students. Of those, 14 boys and 11 girls were in first grade, 23 boys and 23 girls were in second grade, and 28 boys and 21 girls were in third grade, for a total of 65 boys and 55 girls. The total population of the study was 250 students.

Design of the Study

This study was conducted in two parts with nearly identical designs. Both parts of the study included a pretest, instruction, and a posttest, all of which were administered by the teacher of each
classroom of students. Part one of the study, based on instruction in the mathematics skill area of measurement, consisted of three weeks of instruction for all primary students. Part two, based on instruction in the mathematics skill area of place value/regrouping, consisted of three weeks of instruction for first grade students, six weeks for second grade students and four weeks for third grade students.

For the first part of the study, separate analyses were conducted for grades one, two and three. The results of the measurement pretest were analyzed using a one-way analysis of variance design, hereafter referred to as a 1-way ANOVA, to determine and verify equivalence within each grade level between the experimental and the control groups and between males and females. The independent variable of prior achievement groups within each grade was defined as high, middle and low based on pretest scores one standard deviation or greater above the mean (high), one standard deviation or greater below the mean (low), and those in between formed the third group (middle). After three weeks of instruction, all students were given a posttest to determine gain scores in achievement. If the groups within each grade level were found to be equivalent, a three-way analysis of variance design, hereafter referred to as a 3-way ANOVA, was utilized to test for interaction or main effects among the independent variables acting on the dependent variable. If the groups within each grade level were found to be non-equivalent, an analysis of covariance design, hereafter referred to as an ANCOVA, was conducted using the pretest score as a covariate. Therefore, an adjustment was made for non-equivalence to test for interaction or main effects among the independent variables.
acting on the dependent variable (Campbell and Stanley, 1963).

The design of the second part of the study was nearly identical to the first part. Separate analyses were conducted for grades one, two and three. The results of the place value/regrouping pretest were analyzed using a 1-way ANOVA, to determine and verify equivalence within each grade level between the experimental and the control groups and between males and females. The independent variable of prior achievement groups within each grade was defined as high, middle and low based on pretest scores one standard deviation or greater above the mean (high), one standard deviation or greater below the mean (low), and those in between formed the third group (middle). After three weeks of instruction, all students were given a posttest to determine gain scores in achievement. If the groups within each grade level were found to be equivalent, a 3-way ANOVA was utilized to test for interaction or main effects among the independent variables acting on the dependent variable. If the groups within each grade level were found to be non-equivalent, an ANCOVA was conducted using the pretest score as a covariate. Therefore, an adjustment was made for non-equivalence to test for interaction or main effects among the independent variables acting on the dependent variable.

Figure 1 on page 63 illustrates the 3-way ANOVA design for the first part of the study on mathematical measurement. Figure 2 on page 64 illustrates the 3-way ANOVA design for the second part of the study on place value/regrouping. Both figures also illustrate the ANCOVA design that was used if equivalence of groups was not verified.
The independent variables were group, gender and prior achievement. In the layers, H represented high prior achievement, M represented middle, and L represented low. In the rows, C represented the control group of students and E represented the experimental group of students. In the columns, M represented the male students and F represented the females. The dependent variable was achievement represented by the gain score in mathematical measurement calculated by subtracting the pretest score from the posttest score of each student. Using the 3-way ANOVA design for each grade level, main effect rows, main effect columns and main effect layers were analyzed on the dependent variable, as well as an analysis of interaction among the three independent variables.
PART II - THREE WAY ANOVA FOR PLACE VALUE/REGROUPING

The independent variables were group, gender and prior achievement. In the layers, H represented high prior achievement, M represented middle and L represented low. In the rows, C represented the control group of students and E represented the experimental group of students. In the columns, M represented the male students and F represented the females. The dependent variable was achievement represented by the gain score in mathematical place value/regrouping calculated by subtracting the pretest score from the posttest score of each student. Using the 3-way ANOVA design for each grade level, main effect rows, main effect columns and main effect layers were analyzed on the dependent variable, as well as an analysis of interaction among the three independent variables.
Training Sessions

Prior to administering the treatment, ten training sessions on how to integrate mathematics instruction and journal writing were conducted for teachers providing instruction to the experimental group. The rationale for training sessions was based on a recognized need, on how to implement student-centered writing with primary students, following the district-wide inservice writing project and prior to the commencement of this study. Thus, an assumption was made that teachers of primary grade level students required special training on how to effectively implement student-centered writing, such as journals, with their students.

Ten training sessions, lasting approximately ninety minutes each, were conducted by an elementary education professor specializing in language arts instruction and assisted by an elementary education professor specializing in mathematics instruction, both from Montana State University. The language arts education professor provided training based on the Graves's model of student-centered writing and conferencing, with a specific emphasis on journal writing (Graves, 1983). The mathematics education professor provided assistance in how to integrate journal writing with mathematics instruction for primary students.

Seven sessions had been held prior to the conception of this study. Subsequently, the group of five primary school teachers and two professors agreed to participate in a scientific study conducted by the researcher. Training continued for three more sessions, with the
specific interest of this study in mind, resulting in an assumption made by the researcher that the five teachers had developed equal expertise in how to integrate journal writing and mathematics instruction for primary grade level students.

Design of the training sessions allowed for the following objectives to be accomplished:

1. To train teachers of students in the experimental group on methods of implementing student-centered writing and conferencing based on the Graves' model.

2. To specifically train teachers of students in the experimental group on how to teach students to write six types of math journal entries (i.e., prediction, feeling, summary, process, reflection, and story-problem).

3. To provide a one-month period for experimental group teachers to practice teaching mathematics using daily math journals and to write in their own daily math journal as a model for students.

4. To provide a one-month period for parents of primary grade level students to receive math journals home once a week, with encouragement to read them and to write a parent-entry each time.

5. To conduct a primary trait analysis by experts to determine the reliability and validity of identifying the six types of math journal entries written by primary grade level students following
instruction by experimental group teachers.

6. To survey experimental group teachers to determine their recommendations for integrating journals and mathematics instruction for primary students.

7. To survey parents of primary students to determine their recommendations for the continued use of daily math journals.

Analysis of the results of the seven objectives above provided a basis for modification of this study. Decisions were subsequently made on reorganization of the sequence and amount of each type of journal entry to be written by students during the instructional periods of this study. Decisions were also made on the continuation of sending journals home for parents to read and providing parents with suggestions for their written entries.

Treatment

Math instruction included the integration of writing by having students write daily in math journals. Authorities have agreed that one key to mastery of concepts in the field of mathematics was the development of thinking skills (Leutzinger, 1980; Kamii, 1982). Research has verified that writing assists in the development of thinking skills (Murray, 1968; Calkins, 1978; Holt, 1981; Fulwiler, 1982; Graves, 1983; Klein, 1985). Therefore, writing as an integral part of math instruction in primary school was used to assist in the development of thinking skills of primary students. This effort was
made in an attempt to produce larger gains in mathematics achievement.

The students received instruction for writing six different types of entries in their journals. They learned how to write prescription, feeling, process, summary, story-problem and reflection entries. Teachers wrote examples of these entries as they explained them and continued to model the writing of these entries during mathematics instruction. An example of a possible entry that students might write for each type are as follows:

1. prediction - I think we are going to learn to use rulers and measure things like the floor and ceiling. We are going to have fun but hard work.

2. feeling - You shouldn’t have asked me how I felt. I really did not like regrouping because it makes me confused sometimes when you regroup hundreds.

3. process - Dear Desk. Listen to me, because I am going to tell you how to measure. See, you put the ruler on the line and straighten it out so it starts at the end. Then you go across with your finger (you don’t have fingers) until you get to the other end, and read the number on the ruler. That is the inches answer. Easy, huh?

4. summary - Today in class we learned how to regroup numbers into sets of ten. Adding by tens is easy because they all end in zero. We did a bunch of those until recess. The teacher said we had to learn how to regroup because numerals only go up to 9.

5. story-problem - A boy went for a walk and had 17 marbles. He saw a girl with a cookie who had only 9 marbles. She traded her cookie for his 17 marbles. How many marbles did she have now? Answer is 26.

6. reflection - I was right. We did learn to use rulers to measure things, only not the floor or ceiling. We couldn’t get dirty and couldn’t reach the ceiling, so we just measured desks, books, pencils and stuff. I like to write in my journal cause Mom reads it.
Following their participation in ten training sessions, teachers began the school year instructing students in the experimental group on how to write the six types of entries. Prior to the commencement of instruction in mathematical measurement and regrouping, students had written several examples of each type. They applied this as they wrote daily in their math journals. Schedules, established for the study of measurement and for the study of place value/regrouping, directed which type of journal entry would be written by all children in the experimental group and their teachers each day (see Figures 3 and 4).

<table>
<thead>
<tr>
<th>Week</th>
<th>Day</th>
<th>Type of Journal Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
<td>1</td>
<td>prediction</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>summary</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>process</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>feeling</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>process</td>
</tr>
<tr>
<td>two</td>
<td>1</td>
<td>summary</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>process</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>reflection</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>story-problem</td>
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<tr>
<td></td>
<td>5</td>
<td>process</td>
</tr>
<tr>
<td>three</td>
<td>1</td>
<td>story-problem</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>story-problem</td>
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<tr>
<td></td>
<td>3</td>
<td>process</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>feeling</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>reflection</td>
</tr>
</tbody>
</table>

Figure 3

Schedule for Journal Entries
During Measurement Unit
Week - Day - Type of Journal Entry

one - 1 - prediction
   2 - summary
   3 - process
   4 - feeling
   5 - process

two - 1 - summary
   2 - process
   3 - reflection
   4 - story-problem
   5 - process

three - 1 - story-problem
   2 - story-problem
   3 - process
   4 - feeling
   5 - reflection

four - 1 - prediction
   2 - summary
   3 - process
   4 - feeling
   5 - process

five - 1 - summary
   2 - process
   3 - reflection
   4 - story-problem
   5 - process

six - 1 - story-problem
   2 - story-problem
   3 - process
   4 - feeling
   5 - reflection

Figure 4

Schedule for Journal Entries During Place Value/Regrouping Unit
Writing in math journals was considered part of math instruction. On a daily basis, first grade students received a total of forty minutes of math instruction, second grade students received fifty minutes, and third grade students received fifty-five minutes. During the first part of the study involving instruction on mathematical measurement, the treatment lasted three weeks. During the second part of the study involving instruction on place value/regrouping, the treatment lasted three weeks for first grade students, six weeks for second grade students and four weeks for third grade students.

Previous research on students in upper elementary, high school, and college level students had reported positive results on mathematics achievement when writing was integrated with mathematics instruction (Evans, 1984). This study was designed to provide a similar treatment for primary students by using daily math journals as an integral part of mathematics instruction to determine what results, if any, it would produce on mathematics achievement.

This program of treatment differed between the experimental group and the control group in that the experimental group received the treatment by writing in daily math journals during mathematics instruction, and the control group received only the math instruction.

Test Instruments

Primary Math Test for Measurement (PMTM)

The PMTM provided a comprehensive and continuous assessment of skills on mathematical measurement for students in grades one, two and
three. Three levels of the test were designed to correspond to the appropriate grade level for which each is administered. Equivalent forms of each level of the test were identified as pretest and posttest, consisting of identical questions on each form with only the arrangement of questions differing. The test was based on the *Mathematics Around Us* textbook series by Scott, Foresman and Company, 1978. It was designed by the researcher and field-tested in the Devlin Elementary School, Havre Elementary School District #16, Havre, Montana. Consistency was determined by the test-retest method over the period of one week using equivalent forms of the test; this being the most rigorous test of reliability (Gronlund, 1971). The reliability coefficients were .712 for level one, .854 for level two, and .713 for level three. The validity of the PMTM rests on the basis that the test was designed directly from the pages of the textbook which teachers indicated they used for instructional purposes.

The PMTM pretest form was administered to all students in the study during October 1985, directly at the beginning of the study. The scores obtained were used to determine the equivalency of groups using a one-way analysis of variance. The posttest form of the PMTM was administered in November 1985, directly following instruction on mathematical measurement. Scores from the pretest and posttest forms were used in this study to determine gains in achievement.

**Primary Math Test for Place Value/Regrouping (PMTR)**

The PMTR provided a comprehensive and continuous assessment of skills on mathematical place value/ regrouping for students in grades
one, two and three. Three levels of the test were designed to
correspond to the grade level for which each is administered.
Equivalent forms of each level of the test were identified as pretest
and posttest, consisting of identical questions on each form with only
the arrangement of questions differing. The test was based on the
Mathematics Around Us textbook series by Scott, Foresman and Company,
1978. It was designed by the researcher and field-tested in the Devlin
Elementary School, Havre Elementary School District #16, Havre,
Montana. Consistency was determined by the test-retest method over the
period of one week using equivalent forms of the test; this being the
most rigorous test of reliability (Gronlund, 1971). The reliability
coefficients were .844 for level one, .716 for level two, and .814 for
level three. The validity of the PMTR rests on the basis that the test
was designed directly from the pages of the textbook which teachers
indicated they used for instructional purposes.

The PMTR pretest form was administered to all students in the
study in January 1986, directly at the beginning of the study. The
scores obtained were used to determine the equivalency of groups using
a one-way analysis of variance. The posttest form of the PMTR was
administered in February 1986, directly following the instruction on
mathematical place value/regrouping. Scores from the pretest and
posttest forms were used in this study to determine gains in
achievement.
Collection and Organization of Data

Time Schedule

The classroom teachers of students in the experimental and control groups administered the pretests and posttests for the two parts of this study. Using a standard set of directions, they administered the pretest on mathematical measurement during October 1985. Following a three week period of instruction, they administered the posttest on measurement during November 1985. For the second part of the study, all teachers administered a pretest on place value/regrouping during January 1986. Following a three week period of instruction, the first grade teachers administered a posttest on place value/regrouping during February 1986. Second grade students received six weeks of instruction on place value/regrouping and third grade students received four weeks of instruction prior to administering the posttest during February, 1986. All data were collected by March 1, 1986.

Scoring

Each student received raw scores for the pretest and posttest on mathematical measurement. Gain scores for each student were calculated by subtracting the pretest raw score from the posttest raw score. For example, if a student received a raw score of +7 on the pretest on measurement and a raw score of +18 on the posttest, that student’s gain score would be recorded as +11.

Each student received raw scores for the pretest and posttest on place value/regrouping in mathematics. Gain scores were subsequently
calculated by subtracting raw scores of pretests from raw scores of posttests.

Data from the experimental group and the control group were recorded. The data included each student's number, grade level, gender, measurement pretest score, measurement posttest score, place value/regrouping pretest score, place value/regrouping posttest score, prior achievement level in measurement, prior achievement level in place value/regrouping, measurement gain score and place value/regrouping gain score.

### Statistical Hypotheses

The fifty-four hypotheses listed below were tested to resolve the problem as stated in this study (see page 7). All hypotheses were tested at the .05 level of significance.

- \( H_0 \) = There is no significant difference in mean pretest score in mathematical measurement between students in the experimental group and students in the control group in grade one.
- \( H_0 \) = There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade one.
- \( H_0 \) = There is no significant difference in mean pretest score in mathematical measurement among students in the experimental group and students in the control group in grade two.
- \( H_0 \) = There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade two.
- \( H_0 \) = There is no significant difference in mean pretest score in mathematical measurement between students in the experimental group and students in the control group in grade three.
There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade three.

There is no significant interaction in mean gain score in mathematical measurement among group, gender and prior achievement in grade one.

There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade one.

There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade one.

There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade one.

There is no significant difference in mean gain score in mathematical measurement among high, middle and low prior achievement groups in grade one.

There is no significant difference in mean gain score in mathematical measurement between male and female students in grade one.

There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade one.

There is no significant interaction in mean gain score in mathematical measurement among group, gender and prior achievement in grade two.

There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade two.

There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade two.

There is no significant interaction in mean gain score in mathematical measurement between method of instruction and gender in grade two.

There is no significant difference in mean gain score in mathematical measurement between high, middle and low prior achievement groups in grade two.
There is no significant difference in mean gain score in mathematical measurement between male and female students in grade two.

There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade two.

There is no significant interaction in mean gain score in mathematical measurement among group, gender and prior achievement in grade three.

There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade three.

There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade three.

There is no significant interaction in mean gain score in mathematical measurement between method of instruction and gender in grade three.

There is no significant difference in mean gain score in mathematical measurement among high, middle and low prior achievement groups in grade three.

There is no significant difference in mean gain score in mathematical measurement between male and female students in grade three.

There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade three.

There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade one.

There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade one.

There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade two.

There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade two.
There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade three.

There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade three.

There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade one.

There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade one.

There is no significant interaction in mean gain score in place value/regrouping between method of instruction and prior achievement in grade one.

There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade one.

There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade one.

There is no significant difference in mean gain score in place value/regrouping between male and female students in grade one.

There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control in grade one.

There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade two.

There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade two.

There is no significant interaction in mean gain score in place value/regrouping between methods of instruction and prior achievement in grade two.

There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade two.
There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade two.

There is no significant difference in mean gain score in place value/regrouping between male and female students in grade two.

There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control group in grade two.

There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade three.

There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade three.

There is no significant interaction in mean gain score in place value/regrouping between method of instruction and prior achievement in grade three.

There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade three.

There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade three.

There is no significant difference in mean gain score in place value/regrouping between male and female students in grade three.

There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control group in grade three.

Analysis of Data

The analysis of data was completed in two stages. The first stage pertained to data collected relevant to achievement in mathematical measurement. The second stage of analysis pertained to
data collected relevant to achievement in mathematical place value/regrouping.

First, data in the form of pretest raw scores for each grade level were analyzed using a one-way analysis of variance. This was completed to determine equivalency of instructional groups and of gender groups on mathematical measurement prior to instruction. This provided a test of the first six statistical hypotheses. \( F \) ratios were tested at the .05 level of confidence throughout the study.

Following the collection of posttest raw scores, calculations were completed to determine gain scores in achievement on mathematical measurement for each student by subtracting the pretest raw score from the posttest raw score. Then, using a 3-way ANOVA, mean gain scores were analyzed to determine significant interaction or differences among instructional groups, gender and levels of prior achievement. When the 1-way ANOVA results in step one indicated unequal groups, an adjustment was made using an ANCOVA with pretest score used as a covariate. This provided a test of the statistical hypotheses numbered seven through twenty-seven.

Stage two consisted of analyses identical to those in stage one, with the one exception that the analyses were conducted on data relevant to place value/regrouping. Therefore, hypotheses numbered twenty-eight through thirty-three were tested using a 1-way ANOVA to determine equivalency of groups at each grade level. The last twenty-one hypotheses were tested using a 3-way ANOVA if equivalency of groups was determined, or using an ANCOVA with pretest score as a covariate if equivalency of groups was not determined.
The analyses were done at the offices of the Montana Power Company in Butte, Montana, using the SPSSx (Statistical Package for the Social Science, revised).
CHAPTER 4

DATA ANALYSIS AND RESULTS

The major purpose of this study was to determine if there was a significant difference between mean gain score in mathematical achievement of students that received mathematics instruction with daily journal writing and mean gain score of students that received mathematics instruction with no journal writing. Analyses of the independent variables of method of instruction, gender and prior achievement acting on the dependent variable of achievement scores were conducted for grades one, two and three separately.

This study contained two parts. The first part contained data analyses based on mathematics instruction in measurement. The second part contained data analyses based on mathematics instruction in place value/regrouping. Both parts of the study followed the same procedures.

Each student received a grade level pretest, followed by instruction and then a posttest. Pretest scores were analyzed to determine if equality between experimental and control groups existed as a result of the sampling process used. A 1-way ANOVA was used to compare the pretest means of the experimental and control groups. An identical analysis was used to determine equality of gender groups. Six null hypotheses were formulated to test the equality of groups.

Pretest scores were also used to identify high, middle and low prior achievement groups. High prior achievement was indicated by a
pretest score that was greater than or equal to one standard deviation from the mean, low prior achievement was indicated by a pretest score that was less than or equal to one standard deviation below the mean, and middle prior achievement was indicated by those scores in between.

Gain scores were obtained for each grade level by subtracting pretest scores from posttest scores. Twenty-one null hypotheses were formulated to investigate the comparative relationship of mathematics instruction that included daily math journals and mathematics instruction that did not include daily math journals. When equality of groups was determined, a 3-way ANOVA was used to determine if there were any significant differences between the mean gain score of each group at each grade level. When groups were determined to be significantly unequal, an ANCOVA was used to determine if there were any significant differences between the mean gain score of each group at each grade level, utilizing pretest score as a covariate to adjust for inequality.

Each part of the study contained six hypotheses to test the equality of groups prior to instruction and twenty-one hypotheses to investigate comparative relationships of independent variables following instruction. Therefore, a total of fifty-four null hypotheses were tested in this study. The level of significance was set at p < .05.

The tables on the following page illustrate the high, middle and low groups based on pretest score as an indicator of prior achievement. Each table is broken down by instructional groups within each grade level.
### Table 1

Number of Students in Prior Achievement Groups

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Experimental High</th>
<th>Middle</th>
<th>Low</th>
<th>Control High</th>
<th>Middle</th>
<th>Low</th>
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</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>7</td>
<td>14</td>
<td>5</td>
<td>6</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Grade 2</td>
<td>12</td>
<td>24</td>
<td>7</td>
<td>6</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Grade 3</td>
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<td>27</td>
<td>12</td>
<td>10</td>
<td>24</td>
<td>11</td>
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</table>

<table>
<thead>
<tr>
<th>Place Value/Regrouping</th>
<th>Experimental High</th>
<th>Middle</th>
<th>Low</th>
<th>Control High</th>
<th>Middle</th>
<th>Low</th>
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</thead>
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<tr>
<td>Grade 2</td>
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<td>20</td>
<td>9</td>
<td>4</td>
<td>24</td>
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<td>Grade 3</td>
<td>15</td>
<td>30</td>
<td>4</td>
<td>9</td>
<td>16</td>
<td>19</td>
</tr>
</tbody>
</table>
Relevant Data and Findings

Measurement

H₀ There is no significant difference in mean pretest score in mathematical measurement between students in the experimental group and students in the control group in grade one.

The comparison of the mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in measurement. The mean pretest score of the experimental group was 9.00 with a standard deviation of 3.74. The mean pretest score of the control group was 8.30 with a standard deviation of 3.42 (Table 2). The 1-way ANOVA yielded an F ratio of 0.46, a statistic that was not significant beyond the .05 level (p = 0.5091) (Table 3). This finding led to the retention of the null hypothesis, H₀.

H₁ There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade one.

The comparison of the mean pretest score of the male students with that of the female students was used to determine if equality existed between the two groups prior to instruction in measurement. The pretest score mean of the males was 8.81 with a standard deviation of 3.76. The pretest score mean of the females was 8.50 with a standard deviation of 3.41 (Table 2). The 1-way ANOVA yielded an F ratio of 0.09, a statistic that was not significant beyond the .05 level (p = 0.7603) (Table 3). This finding led to the retention of the
Table 2

Means and Standard Deviation of Measurement Pretest Scores

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
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<td></td>
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<tr>
<td>EXPEDMENTAL</td>
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<tr>
<td>Grade 1</td>
<td>26</td>
<td>9.00</td>
<td>3.74</td>
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<td>8.30</td>
<td>3.42</td>
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<td>Grade 2</td>
<td>43</td>
<td>13.72</td>
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<td>13.40</td>
<td>3.80</td>
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<td>50</td>
<td>18.32</td>
<td>3.85</td>
<td>45</td>
<td>18.11</td>
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<table>
<thead>
<tr>
<th>GENDER</th>
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<th>FEMALES</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Grade 1</td>
<td>27</td>
<td>8.81</td>
<td>3.76</td>
<td>22</td>
<td>8.30</td>
</tr>
<tr>
<td>Grade 2</td>
<td>42</td>
<td>14.12</td>
<td>4.16</td>
<td>44</td>
<td>13.02</td>
</tr>
<tr>
<td>Grade 3</td>
<td>51</td>
<td>18.78</td>
<td>3.67</td>
<td>44</td>
<td>17.57</td>
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</table>
null hypothesis, $H_0^2$.

$H_0^2$ = There is no significant difference in mean pretest score in mathematical measurement between students in the experimental group and students in the control group in grade two.

The comparison mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in measurement. The mean pretest score of the experimental group was 13.72 with a standard deviation of 4.75. The mean pretest score of the control group was 13.40 with a standard deviation of 3.90 (Table 2). The 1-way ANOVA yielded an F ratio of 0.12, a statistic that was not significant beyond the .05 level ($p = 0.7291$) (Table 3). This finding led to the retention of the null hypothesis, $H_0^3$.

$H_0^3$ = There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade two.

The comparison of the mean pretest score of the male students with that of the female students was used to determine if equality existed between the two groups prior to instruction in measurement. The mean pretest score of the males was 14.12 with a standard deviation of 4.16. The mean pretest score of the females was 13.02 with a standard deviation of 4.45 (Table 2). The 1-way ANOVA yielded an F ratio of 1.39, a statistic that was not significant beyond the .05 level ($p = 0.2401$) (Table 3). This finding led to retention of the
Table 3

Comparison of Pretest Mean Scores in Measurement Using a One Way ANOVA: Experimental and Control and Males and Females

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental Means</th>
<th>Control Means</th>
<th>F</th>
<th>df</th>
<th>p value</th>
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<td>Grade 1</td>
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<td>Grade 2</td>
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<td>1</td>
<td>0.7819</td>
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<table>
<thead>
<tr>
<th>Variables</th>
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<th>Females Means</th>
<th>F</th>
<th>df</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>8.81</td>
<td>8.50</td>
<td>0.09</td>
<td>1</td>
<td>0.7603</td>
</tr>
<tr>
<td>Grade 2</td>
<td>14.12</td>
<td>13.02</td>
<td>1.39</td>
<td>1</td>
<td>0.2401</td>
</tr>
<tr>
<td>Grade 3</td>
<td>18.78</td>
<td>17.57</td>
<td>2.59</td>
<td>1</td>
<td>0.1071</td>
</tr>
</tbody>
</table>

* = significant at the .05 level

NS = not significant
null hypothesis, $H_{0}$

$H_{0}^4$ = There is no significant difference in mean pretest score in mathematical measurement between students in the experimental group and students in the control group in grade three.

The comparison of the mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in mathematical measurement. The mean pretest score of the experimental group was 18.32 with a standard deviation of 3.85. The mean pretest score of the control group was 18.11 with a standard deviation of 3.58 (Table 2). The 1-way ANOVA yielded an F ratio of 0.07, a statistic that was not significant beyond the .05 level ($p = 0.7819$) (Table 3). This finding led to the retention of the null hypothesis, $H_{0}^5$.

$H_{0}^5$ = There is no significant difference in mean pretest score in mathematical measurement between male students and female students in grade three.

The comparison of the mean pretest score of the male students with that of the female students was used to determine if equality existed between the two groups prior to instruction in measurement. The mean pretest score of the males was 18.78 with a standard deviation of 3.67. The mean pretest score of the females was 17.57 with a standard deviation of 3.68 (Table 2). The 1-way ANOVA yielded an F ratio of 2.59, a statistic that was not significant beyond the .05 level ($p = 0.1071$) (Table 3). This finding led to the retention of
the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in mathematical measurement among group, gender and prior achievement in grade one.

The comparison of the mean gain score in mathematical measurement of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. The data obtained by the 3-way ANOVA yielded an $F$ ratio of 2.318, a statistic that was not significant beyond the .05 level ($p = 0.113$) (Table 5). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade one.

The comparison of the mean gain score in mathematical measurement of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an $F$ ratio of 0.47, a statistic that was not significant beyond the .05 level ($p = 0.629$) (Table 5). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade one.

The comparison of the mean gain score in mathematical measurement
Table 4
Means and Standard Deviation of Measurement Gain Scores

<table>
<thead>
<tr>
<th></th>
<th><strong>GROUP</strong></th>
<th><strong>EXPERIMENTAL</strong></th>
<th><strong>CONTROL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>N</strong></td>
<td><strong>Mean</strong></td>
<td><strong>S.D.</strong></td>
</tr>
<tr>
<td><strong>Grade 1</strong></td>
<td>26</td>
<td>3.88</td>
<td>3.70</td>
</tr>
<tr>
<td><strong>Grade 2</strong></td>
<td>43</td>
<td>4.16</td>
<td>4.44</td>
</tr>
<tr>
<td><strong>Grade 3</strong></td>
<td>50</td>
<td>4.16</td>
<td>3.72</td>
</tr>
<tr>
<td><strong>GROUP</strong></td>
<td><strong>EXPERIMENTAL</strong></td>
<td><strong>MALES</strong></td>
<td><strong>FEMALES</strong></td>
</tr>
<tr>
<td><strong>Grade 1</strong></td>
<td>27</td>
<td>4.41</td>
<td>2.46</td>
</tr>
<tr>
<td><strong>Grade 2</strong></td>
<td>42</td>
<td>3.95</td>
<td>3.41</td>
</tr>
<tr>
<td><strong>Grade 3</strong></td>
<td>51</td>
<td>4.04</td>
<td>2.93</td>
</tr>
<tr>
<td><strong>GROUP</strong></td>
<td><strong>EXPERIMENTAL</strong></td>
<td><strong>HIGH</strong></td>
<td><strong>MIDDLE</strong></td>
</tr>
<tr>
<td><strong>Grade 1</strong></td>
<td>13</td>
<td>0.15</td>
<td>1.41</td>
</tr>
<tr>
<td><strong>Grade 2</strong></td>
<td>18</td>
<td>0.11</td>
<td>1.23</td>
</tr>
<tr>
<td><strong>Grade 3</strong></td>
<td>21</td>
<td>0.95</td>
<td>1.86</td>
</tr>
</tbody>
</table>
of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an F ratio of 0.567, a statistic that was not significant beyond the .05 level ($p = 0.572$) (Table 5). This finding led to the retention of the null hypothesis,

\[ H_0 \]

\[ H_0 = \text{There is no significant interaction in mean gain score in mathematical measurement between method of instruction and gender in grade one.} \]

The comparison of the mean gain score in mathematical measurement of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. The 3-way ANOVA yielded an F ratio of 0.046, a statistic that was not significant beyond the .05 level ($p = 0.832$) (Table 5). This finding led to the retention of the null hypothesis, $H_0$.

\[ H_0 \]

\[ H_0 = \text{There is no significant difference in mean gain score in mathematical measurement among high, middle and low prior achievement groups in grade one.} \]

The comparison of the mean gain score in mathematical measurement of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the groups achieved significantly higher gains than the others. The mean gain scores of the three groups were 0.15 for the high group, 4.78 for the middle group and 8.11 for the low group. Students in the low group
made the most gain, and students in the high group made the least gain. The 3-way ANOVA yielded an F ratio of 39.94, a statistic that was significant beyond the .05 level (p = 0.000) (Table 5). This finding led to the rejection of the null hypothesis, H

\[ H_0 \]

\[ H = \text{There is no significant difference in mean gain score in mathematical measurement between male and female students in grade one.} \]

The comparison of the mean gain score in mathematical measurement of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The mean gain score of the male students was 4.41 with a standard deviation of 3.47. The mean gain score of the female students was 3.86 with a standard deviation of 3.43 (Table 4). The 3-way ANOVA yielded an F ratio of 0.56, a statistic that was not significant beyond the .05 level (p = 0.461) (Table 5). This finding led to the retention of the null hypothesis, H

\[ H_0 \]

\[ H = \text{There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade one.} \]

The comparison of the mean gain score in mathematical measurement of the students in the experimental group with that of the students in the control group was used to determine if method of instruction resulted in significantly higher gains in achievement. The mean gain score of the experimental group was 3.88 with a standard deviation of 3.70. The mean gain score of the control group was 4.48 with a standard deviation of 3.13 (Table 4). The 3-way ANOVA yielded an F
Table 5
Three-way ANOVA Comparing Mean Gain Scores for Measurement in Grade 1

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Group</td>
<td>4.456</td>
<td>1,37</td>
<td>4.456</td>
<td>0.992</td>
<td>0.326</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td>2.498</td>
<td>1,37</td>
<td>2.498</td>
<td>0.556</td>
<td>0.461</td>
<td>NS</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>358.903</td>
<td>2,37</td>
<td>179.452</td>
<td>39.937</td>
<td>0.000</td>
<td>*</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>0.206</td>
<td>1,37</td>
<td>0.026</td>
<td>0.046</td>
<td>0.832</td>
<td>NS</td>
</tr>
<tr>
<td>Group X Prior Achievement</td>
<td>5.099</td>
<td>2,37</td>
<td>2.549</td>
<td>0.567</td>
<td>0.572</td>
<td>NS</td>
</tr>
<tr>
<td>Gender X Prior Achievement</td>
<td>4.223</td>
<td>2,37</td>
<td>2.111</td>
<td>0.470</td>
<td>0.629</td>
<td>NS</td>
</tr>
<tr>
<td>Group X Gender X Prior Achievement</td>
<td>20.833</td>
<td>2,37</td>
<td>10.417</td>
<td>2.318</td>
<td>0.113</td>
<td>NS</td>
</tr>
<tr>
<td>Error</td>
<td>166.256</td>
<td>37</td>
<td>4.493</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = significant at the .05 level

NS = not significant
ratio of 0.992, a statistic that was not significant beyond the .05 level (p = 0.326) (Table 5). This finding led to the retention of the null hypothesis, \( H_0 \).

\[ H_0 = \text{There is no significant interaction in mean gain score in mathematical measurement group, gender and prior achievement in grade two.} \]

The comparison of the mean gain score in mathematical measurement of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. The data obtained by the 3-way ANOVA yielded an F ratio of 3.013, a statistic that was not significant beyond the .05 level (p = 0.055) (Table 6). This finding led to the retention of the null hypothesis, \( H_0 \).

\[ H_0 = \text{There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade two.} \]

The comparison of the mean gain score in mathematical measurement of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an F ratio of 1.579, a statistic that was not significant beyond the .05 level (p = 0.213) (Table 6). This finding led to the retention of the null hypothesis, \( H_0 \).
H = There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade two.

The comparison of the mean gain score in mathematical measurement of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an F ratio of 2.768, a statistic that was not significant beyond the .05 level \((p = 0.069)\) (Table 6). This finding led to the retention of the null hypothesis, \(H_0\).

\(H_{16} = \) There is no significant interaction in mean gain score in mathematical measurement between method of instruction and gender in grade two.

The comparison of the mean gain score in mathematical measurement of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. The 3-way ANOVA yielded an F ratio of 0.378, a statistic that was not significant beyond the .05 level \((p = 0.541)\) (Table 6). This finding led to the retention of the null hypothesis, \(H_0\).

\(H_{17} = \) There is no significant difference in mean gain score in mathematical measurement among high, middle and low prior achievement groups in grade two.

The comparison of the mean gain score in mathematical measurement of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the
### Table 6

Three-way ANOVA Comparing Mean Gain Scores for Measurement in Grade 2

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1.670</td>
<td>1,74</td>
<td>1.670</td>
<td>0.224</td>
<td>0.638</td>
</tr>
<tr>
<td>Gender</td>
<td>1.68</td>
<td>1,74</td>
<td>1.768</td>
<td>0.237</td>
<td>0.628</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>700.869</td>
<td>2,74</td>
<td>350.435</td>
<td>46.894</td>
<td>0.000</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>2.824</td>
<td>1,74</td>
<td>2.824</td>
<td>0.378</td>
<td>0.541</td>
</tr>
<tr>
<td>Group X Prior Achievement</td>
<td>41.365</td>
<td>2,74</td>
<td>20.682</td>
<td>2.768</td>
<td>0.069</td>
</tr>
<tr>
<td>Gender X Prior Achievement</td>
<td>23.596</td>
<td>2,74</td>
<td>11.798</td>
<td>1.579</td>
<td>0.213</td>
</tr>
<tr>
<td>Group X Gender X Prior Achievement</td>
<td>45.033</td>
<td>2,74</td>
<td>22.517</td>
<td>3.013</td>
<td>0.055</td>
</tr>
</tbody>
</table>

| Error                         | 552.993        | 74  | 7.473        |

* = significant at the .05 level

NS = not significant
groups achieved significantly higher gains than the others. The mean gain scores of the three groups were 0.11 for the high group, 4.38 for the middle group and 9.47 for the low group. Students in the low group made the most gain, and students in the high group made the least gain. The 3-way ANOVA yielded an F ratio of 46.894, a statistic that was significant beyond the .05 level (p = 0.000) (Table 6). This finding led to the rejection of the null hypothesis, H

H = There is no significant difference in mean gain score in mathematical measurement between male and female students in grade two.

The comparison of the mean gain score in mathematical measurement of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The mean gain score of the male students was 3.95 with a standard deviation of 3.41. The mean gain score of the female students was 4.77 with a standard deviation of 4.58 (Table 4). The 3-way ANOVA yielded an F ratio of 0.237, a statistic that was not significant beyond the .05 level (p = 0.628) (Table 6). This finding led to the retention of the null hypothesis, H

H = There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade two.

The comparison of the mean gain score in mathematical measurement of the students in the experimental group with that of the students in the control group was used to determine if method of instruction resulted in significantly higher gains in achievement. The mean gain...
score of the experimental group was 4.16 with a standard deviation of 4.44. The mean gain score of the control group was 4.58 with a standard deviation of 3.64 (Table 4). The 3-way ANOVA yielded an F ratio of 0.224, a statistic that was not significant beyond the .05 level \( p = 0.638 \) (Table 6). This finding led to the retention of the null hypothesis, \( H_0 \):

\[ H_0 = \text{There is no significant interaction in mean gain score in mathematical measurement among group, gender and prior achievement in grade three.} \]

The comparison of the mean achievement gain score in mathematical measurement of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. The data obtained by the 3-way ANOVA yielded an F ratio of 0.062, a statistic that was not significant beyond the .05 level \( p = 0.040 \) (Table 7). This finding led to the retention of the null hypothesis, \( H_0 \):

\[ H_0 = \text{There is no significant interaction in mean gain score in mathematical measurement between gender and prior achievement in grade three.} \]

The comparison of the mean gain score in mathematical measurement of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an F ratio of 0.170, a statistic that was not significant beyond the .05 level \( p = 0.844 \) (Table 7). This finding
Three-way ANOVA Comparing Mean Gain Scores for Measurement in Grade 3

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>9.028</td>
<td>1,83</td>
<td>9.028</td>
<td>1.401</td>
<td>0.240</td>
</tr>
<tr>
<td>Gender</td>
<td>0.883</td>
<td>1,83</td>
<td>0.883</td>
<td>0.137</td>
<td>0.712</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>486.689</td>
<td>2,83</td>
<td>243.344</td>
<td>37.772</td>
<td>0.000</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>11.143</td>
<td>1,83</td>
<td>11.143</td>
<td>1.730</td>
<td>0.192</td>
</tr>
<tr>
<td>Group X Prior Achievement</td>
<td>7.977</td>
<td>2,83</td>
<td>3.989</td>
<td>0.619</td>
<td>0.541</td>
</tr>
<tr>
<td>Gender X Prior Achievement</td>
<td>2.189</td>
<td>2,83</td>
<td>1.094</td>
<td>0.170</td>
<td>0.844</td>
</tr>
<tr>
<td>Group X Gender X Prior Achievement</td>
<td>0.797</td>
<td>2,83</td>
<td>0.399</td>
<td>0.062</td>
<td>0.940</td>
</tr>
<tr>
<td>Error</td>
<td>534.729</td>
<td>83</td>
<td>6.443</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = significant beyond the .05 level
NS = not significant
led to the retention of the null hypothesis, $H_0$

$H_0$ = There is no significant interaction in mean gain score in mathematical measurement between method of instruction and prior achievement in grade three.

The comparison of the mean gain score in mathematical measurement of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The 3-way ANOVA yielded an F ratio of 0.619, a statistic that was not significant beyond the .05 level ($p = 0.541$) (Table 7). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in mathematical measurement between method of instruction and gender in grade one.

The comparison of the mean gain score in mathematical measurement of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. The 3-way ANOVA yielded an F ratio of 1.730, a statistic that was not significant beyond the .05 level ($p = 0.192$) (Table 7). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant difference in mean gain score in mathematical measurement among high, middle and low prior achievement groups in grade three.

The comparison of the mean gain score in mathematical measurement
of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the groups achieved significantly higher gains than the others. The mean gain scores of the three groups were 0.95 for the high group, 4.41 for the middle group and 7.74 for the low group. Students in the low group made the most gain, and students in the high group made the least gain. The 3-way ANOVA yielded an F ratio of 37.772, a statistic that was significant beyond the .05 level (p = .000) (Table 7). This finding led to the rejection of the null hypothesis, $H_0$.

$H_0$: There is no significant difference in mean gain score in mathematical measurement between male and female students in grade three.

The comparison of the mean gain score in mathematical measurement of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The mean gain score of the male students was 4.04 with a standard deviation of 2.93. The mean gain score of the female students was 4.93 with a standard deviation of 3.36 (Table 4). The 3-way ANOVA yielded an F ratio of .137, a statistic that was not significant beyond the .05 level (p = .712) (Table 7). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$: There is no significant difference in mean gain score in mathematical measurement between students in the experimental group and students in the control group in grade three.

The comparison of the mean gain score in mathematical measurement of the students in the experimental group with that of the students in
the control group was used to determine if method of instruction resulted in significantly higher gains in achievement. The mean gain score of the experimental group was 4.16 with a standard deviation of 3.72. The mean gain score of the control group was 4.78 with a standard deviation of 2.96 (Table 4). The 3-way ANOVA yielded an F ratio of 1.401, a statistic that was not significant beyond the .05 level (p = 0.240) (Table 7). This finding led to the retention of the null hypothesis, $H_0$.

**Place Value/Regrouping**

$H_0$: There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade one.

The comparison of the mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in place value/regrouping. The mean pretest score of the experimental group was 3.28 with a standard deviation of 2.19. The mean pretest score of the control group was 9.09 with a standard deviation of 2.64 (Table 8). The 1-way ANOVA yielded an F ratio of 69.11, a statistic that is significant beyond the .05 level (p = .000) (Table 9). This finding led to the rejection of the null hypothesis, $H_0$.

$H_0$: There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade one.

The comparison of the mean pretest score of the male students
Table 8
Means and Standard Deviation of Place Value/Regrouping Pretest Scores

<table>
<thead>
<tr>
<th>GROUP</th>
<th>EXPERIMENTAL</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>CONTROL</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
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</thead>
<tbody>
<tr>
<td>Grade 1</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>25</td>
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<td>Grade 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>46</td>
<td></td>
<td>10.43</td>
<td>3.41</td>
<td>45</td>
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<td>49</td>
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<td>13.71</td>
<td>3.33</td>
<td>46</td>
<td></td>
<td>10.61</td>
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<td></td>
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<td>FEMALES</td>
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</tr>
<tr>
<td>Grade 1</td>
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<td></td>
<td></td>
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<td>6.04</td>
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<tr>
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<td>12.37</td>
<td>4.72</td>
<td>44</td>
<td></td>
<td>12.02</td>
<td>4.47</td>
</tr>
</tbody>
</table>
with that of the female students was used to determine if equality existed between the two groups prior to instruction in measurement. The pretest score mean of the males was 6.04 with a standard deviation of 3.77. The pretest score mean of the females was 6.10 with a standard deviation of 3.91 (Table 8). The 1-way ANOVA yielded an F ratio of 0.00, a statistic that is not significant beyond the .05 level (p = .9532) (Table 9). This finding led to the retention of the null hypothesis, $H_0$.

H = There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade two.

The comparison mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in place value/regrouping. The mean pretest score of the experimental group was 10.43 with a standard deviation of 3.41. The mean pretest score of the control group was 8.98 with a standard deviation of 2.80 (Table 8). The 1-way ANOVA yielded an F ratio of 4.95, a statistic that was significant at the .05 level (p = 0.0269) (Table 9). This finding led to the rejection of the null hypothesis, $H_0$.

H = There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade two.

The comparison of the mean pretest score of the male students with that of the female students was used to determine if equality existed between the two groups prior to instruction in place value/regrouping.
### Table 9
Comparison of Pretest Mean Scores in Place Value/Regrouping Using a One Way ANOVA: Experimental and Control and Males and Females

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental Means</th>
<th>Control Means</th>
<th>F</th>
<th>df</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>3.28</td>
<td>9.09</td>
<td>69.11</td>
<td>1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Grade 2</td>
<td>10.43</td>
<td>8.98</td>
<td>4.95</td>
<td>1</td>
<td>0.0269</td>
</tr>
<tr>
<td>Grade 3</td>
<td>13.71</td>
<td>10.61</td>
<td>12.17</td>
<td>1</td>
<td>0.0011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Males Means</th>
<th>Females Means</th>
<th>F</th>
<th>df</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>6.04</td>
<td>6.10</td>
<td>0.00</td>
<td>1</td>
<td>0.9532</td>
</tr>
<tr>
<td>Grade 2</td>
<td>10.00</td>
<td>9.43</td>
<td>0.71</td>
<td>1</td>
<td>0.4107</td>
</tr>
<tr>
<td>Grade 3</td>
<td>12.37</td>
<td>12.02</td>
<td>0.14</td>
<td>1</td>
<td>0.7141</td>
</tr>
</tbody>
</table>

* = significant at the .05 level

NS = not significant
value/regrouping. The mean pretest score of the males was 10.00 with a standard deviation of 3.34. The mean pretest score of the females was 9.43 with a standard deviation of 3.05 (Table 8). The 1-way ANOVA yielded an F ratio of 0.01, a statistic that was not significant beyond the .05 level (p = 0.7141) (Table 9). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant difference in mean pretest score in place value/regrouping between students in the experimental group and students in the control group in grade three.

The comparison of the mean pretest score of the experimental group with that of the control group was used to determine if equality existed between the two groups prior to instruction in place value/regrouping. The mean pretest score of the experimental group was 13.71 with a standard deviation of 3.33. The mean pretest score of the control group was 10.61 with a standard deviation of 5.20 (Table 8). The 1-way ANOVA yielded an F ratio of 12.17, a statistic that was significant beyond the .05 level (p = 0.0011) (Table 9). This finding led to the rejection of the null hypothesis, $H_0$.

$H_0$ = There is no significant difference in mean pretest score in place value/regrouping between the male and female students in grade three.

The comparison of the mean pretest score of the male students with that of the female students was used to determine if equality existed between the two groups prior to instruction in place value/regrouping. The mean pretest score of the males was 12.37 with a standard deviation of 4.72. The mean pretest score of the females was
12.02 with a standard deviation of 4.47 (Table 8). The 1-way ANOVA yielded an F ratio of 0.14, a statistic that was not significant beyond the .05 level (p = 0.7141) (Table 9). This finding led to the retention of the null hypothesis, $H_0$.

$$H_0 = \text{There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade one.}$$

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. Due to some empty cells in the ANCOVA, it was not possible to determine if interaction occurred (Table 11). This finding led to the retention of the null hypothesis, $H_0$.

$$H_0 = \text{There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade one.}$$

The comparison of the adjusted mean gain score in place value/regrouping of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. Due to empty cells in the ANCOVA, it was not possible to determine if interaction occurred (Table 11). This finding led to the retention of the null hypothesis, $H_0$.

$$H_0 = \text{There is no significant interaction in mean gain score in place value/regrouping between prior achievement groups in grade one.}$$
### Table 10

Adjusted Means and Amount of Adjustment for Place Value/Regrouping Gain Scores

<table>
<thead>
<tr>
<th>GROUP</th>
<th>EXPERIMENTAL</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Gain Score</td>
<td>N</td>
</tr>
<tr>
<td>Grade 1</td>
<td>3.89</td>
<td>23</td>
</tr>
<tr>
<td>Grade 2</td>
<td>5.65</td>
<td>44</td>
</tr>
<tr>
<td>Grade 3</td>
<td>4.59</td>
<td>49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENDER</th>
<th>MALES</th>
<th>FEMALES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>2.03</td>
<td>1.64</td>
</tr>
<tr>
<td>Grade 2</td>
<td>4.58</td>
<td>6.09</td>
</tr>
<tr>
<td>Grade 3</td>
<td>4.38</td>
<td>4.13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRIOR ACHIEVEMENT</th>
<th>HIGH</th>
<th>MIDDLE</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>0.10</td>
<td>2.39</td>
<td>3.22</td>
</tr>
<tr>
<td>Grade 2</td>
<td>3.90</td>
<td>4.05</td>
<td>8.99</td>
</tr>
<tr>
<td>Grade 3</td>
<td>-1.06</td>
<td>6.06</td>
<td>5.47</td>
</tr>
</tbody>
</table>
H₀ = There is no significant interaction in mean gain score in place value/regrouping between method of instruction and prior achievement in grade one.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. Due to some empty cells in the ANCOVA, it was not possible to determine if interaction occurred (Table 11). This finding led to the retention of the null hypothesis, H₀.

H₀ = There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade one.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. Due to some empty cells in the ANCOVA, it was not possible to determine if interaction occurred (Table 11). This finding led to the retention of the null hypothesis, H₀.

H₀ = There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade one.

The comparison of the adjusted mean gain score in place value/regrouping of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the groups achieved significantly higher gains than the
Table 11

ANCOVA Comparing Mean Gain Scores for Place Value/Regrouping in Grade 1 using Pretest Scores as a Covariate

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>7.109</td>
<td>1,39</td>
<td>7.109</td>
<td>1.817</td>
<td>0.185</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td>0.767</td>
<td>1,39</td>
<td>0.767</td>
<td>0.196</td>
<td>0.660</td>
<td>NS</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>0.178</td>
<td>2,39</td>
<td>0.089</td>
<td>0.023</td>
<td>0.978</td>
<td>NS</td>
</tr>
<tr>
<td>Error</td>
<td>152.611</td>
<td>39</td>
<td>3.913</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Covariate = -0.405 Raw Regression Coefficient

Note: Due to empty cells, higher order interactions were suppressed.

* = significant at the .05 level

NS = not significant
others. The adjusted mean gain scores of the three groups were 0.10 for the high group, 2.39 for the middle group and 3.22 for the low group (Table 10). Students in the low group made the most gain, and students in the high group made the least gain. The ANCOVA yielded an F ratio of 0.023, a statistic that was significant beyond the .05 level (p = 0.978) (Table 11). This finding led to the retention of the null hypothesis, \( H_0 \).

\[ H_0 = \text{There is no significant difference in mean gain score in place value/regrouping between male and female students in grade one.} \]

The comparison of the adjusted mean gain score in place value/regrouping of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The adjusted mean gain score of the male students was 2.03. The adjusted mean gain score of the female students was 1.64 (Table 10). The ANCOVA yielded an F ratio of 0.196, a statistic that was not significant beyond the .05 level (p = 0.660) (Table 11). This finding led to the retention of the null hypothesis, \( H_0 \).

\[ H_0 = \text{There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control group in grade one.} \]

The comparison of the adjusted mean gain score in place value/regrouping of the students in the experimental group with that of the students in the control group was used to determine if method of instruction resulted in significantly higher gains in achievement. The
adjusted mean gain score of the experimental group was 3.89. The adjusted mean gain score of the control group was -0.35 (Table 10). The ANCOVA yielded an F ratio of 1.817, a statistic that is not significant beyond the .05 level (p = 0.185) (Table 11). This finding led to the retention of the null hypothesis, $H_0$.

$H_0 =$ There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade two.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. The data obtained by the ANCOVA yielded an F ratio of 0.484, a statistic that was not significant beyond the .05 level (p = 0.618) (Table 12). This finding led to the retention of the null hypothesis, $H_0$.

$H_0 =$ There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade two.

The comparison of the adjusted mean gain score in place value/regrouping of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The ANCOVA yielded an F ratio of 0.243, a statistic that was not significant beyond the .05 level (p = 0.785)
Table 12

ANOVA Comparing Mean Gain Scores for Place Value/Regrouping in Grade 2 using Pretest Scores as a Covariate

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>8.763</td>
<td>1,73</td>
<td>8.763</td>
<td>1.076</td>
<td>0.303</td>
</tr>
<tr>
<td>Gender</td>
<td>10.556</td>
<td>1,73</td>
<td>10.556</td>
<td>1.296</td>
<td>0.259</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>33.377</td>
<td>2,73</td>
<td>16.689</td>
<td>2.049</td>
<td>0.136</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>31.656</td>
<td>1,73</td>
<td>31.656</td>
<td>3.886</td>
<td>0.052</td>
</tr>
<tr>
<td>Group X Prior Achievement</td>
<td>12.210</td>
<td>2,73</td>
<td>6.105</td>
<td>0.749</td>
<td>0.476</td>
</tr>
<tr>
<td>Gender X Prior Achievement</td>
<td>3.963</td>
<td>2,73</td>
<td>1.981</td>
<td>0.243</td>
<td>0.785</td>
</tr>
<tr>
<td>Group X Gender X Prior Achievement</td>
<td>7.893</td>
<td>2,73</td>
<td>3.946</td>
<td>0.484</td>
<td>0.618</td>
</tr>
<tr>
<td>Error</td>
<td>594.658</td>
<td>73</td>
<td>8.146</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Covariate = -0.511 Raw Regression Coefficient

* = significant beyond the .05 level

NS = not significant
(Table 12). This finding led to the retention of the null hypothesis,

\[ H_0 = \text{There is no significant interaction in mean gain score in place value/regrouping between method of instruction and prior achievement in grade two.} \]

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The ANCOVA yielded an F ratio of 0.749, a statistic that was not significant beyond the .05 level \((p = 0.476)\) (Table 12). This finding led to the retention of the null hypothesis,

\[ H_0 = \text{There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade two.} \]

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. The ANCOVA yielded an F ratio of 3.886, a statistic that was not significant beyond the .05 level \((p = 0.052)\) (Table 12). This finding led to the retention of the null hypothesis,

\[ H_0 = \text{There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade two.} \]
The comparison of the adjusted mean gain score in place value/regrouping of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the groups achieved significantly higher gains than the others. The adjusted mean gain scores of the three groups were 3.90 for the high group, 4.05 for the middle group and 8.99 for the low group (Table 10). The ANCOVA yielded an F ratio of 2.049, a statistic that was significant beyond the .05 level (p = 0.136) (Table 12). This finding led to the retention of the null hypothesis, \( H_0 \),

\[ H_0 = \text{There is no significant difference in mean gain score in place value/regrouping between male and female students in grade two.} \]

The comparison of the adjusted mean gain score in place value/regrouping of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The adjusted mean gain score of the male students was 4.58. The mean gain score of the female students was 6.09 (Table 10). The ANCOVA yielded an F ratio of 1.296, a statistic that was not significant beyond the .05 level (p = 0.259) (Table 12). This finding led to the retention of the null hypothesis, \( H_0 \),

\[ H_0 = \text{There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control group in grade two.} \]

The comparison of the adjusted mean gain score in place value/regrouping of the students in the experimental group with that of the students in the control group was used to determine if method of
instruction resulted in significantly higher gains in achievement. The adjusted mean gain score of the experimental group was 5.65. The mean gain score of the control group was 5.02 (Table 10). The ANCOVA yielded an F ratio of 1.076, a statistic that was not significant beyond the .05 level (p = 0.303) (Table 12). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in place value/regrouping among group, gender and prior achievement in grade three.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups was used to determine if male or female students as high, middle or low achievers could achieve significantly higher gains when instructed with a particular method. The data obtained by the ANCOVA yielded an F ratio of .0672, a statistic that was significant beyond the .05 level (p = .0513) (Table 13). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in place value/regrouping between gender and prior achievement in grade three.

The comparison of the adjusted mean gain score in place value/regrouping of male and female students with that of prior achievement was used to determine if either gender achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The ANCOVA yielded an F ratio of 1.011, a statistic that was not significant beyond the .05 level (p = 0.369)
Table 13

ANCOVA Comparing Mean Gain Scores for Place Value/Regrouping in Grade 3 using Pretest Scores as a Covariate

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>28.368</td>
<td>1,80</td>
<td>28.368</td>
<td>11.476</td>
<td>0.001   *</td>
</tr>
<tr>
<td>Gender</td>
<td>3.209</td>
<td>1,80</td>
<td>3.209</td>
<td>1.298</td>
<td>0.258   NS</td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>92.781</td>
<td>2,80</td>
<td>46.391</td>
<td>18.767</td>
<td>0.000   *</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>3.123</td>
<td>1,80</td>
<td>3.123</td>
<td>1.263</td>
<td>0.264   NS</td>
</tr>
<tr>
<td>Group X Prior Achievement</td>
<td>65.095</td>
<td>2,80</td>
<td>32.547</td>
<td>13.167</td>
<td>0.000   *</td>
</tr>
<tr>
<td>Gender X Prior Achievement</td>
<td>4.996</td>
<td>2,80</td>
<td>2.498</td>
<td>1.011</td>
<td>0.369   NS</td>
</tr>
<tr>
<td>Group X Gender X Prior</td>
<td>3.324</td>
<td>2,80</td>
<td>1.662</td>
<td>0.672</td>
<td>0.513   NS</td>
</tr>
</tbody>
</table>

Error                          | 197.757        | 80  | 2.472        |

Covariate = -0.469 Raw Regression Coefficient

* = significant beyond the .05 level

NS = not significant
(Table 13). This finding led to the retention of the null hypothesis, $H_0$

$H_0$ = There is no significant interaction in mean gain score in place value/regrouping between method of instruction and prior achievement in grade three.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of prior achievement was used to determine if method of instruction achieved significantly higher gain scores when analyzed by high, middle or low prior achievement groups. The ANCOVA yielded an $F$ ratio of 13.167, a statistic that was significant beyond the .05 level ($p = 0.000$) (Table 13). This finding led to the rejection of the null hypothesis, $H_0$.

$H_0$ = There is no significant interaction in mean gain score in place value/regrouping between method of instruction and gender in grade three.

The comparison of the adjusted mean gain score in place value/regrouping of experimental and control groups with that of male and female students was used to determine if method of instruction achieved higher gain scores when analyzed by gender differences. The ANCOVA yielded an $F$ ratio of 1.263, a statistic that was not significant beyond the .05 level ($p = 0.264$) (Table 13). This finding led to the retention of the null hypothesis, $H_0$.

$H_0$ = There is no significant difference in mean gain score in place value/regrouping among high, middle and low prior achievement groups in grade three.

The comparison of the adjusted mean gain score in place
value/regrouping of the students in the high group with that of the students in the middle and low groups was used to determine if students in one of the groups achieved significantly higher gains than the others. The adjusted mean gain scores of the three groups were -1.06 for the high group, 6.06 for the middle group and 5.47 for the low group (Table 10). Students in the middle group made the most gain, and students in the high group made the least gain. The ANCOVA yielded an F ratio of 18.767, a statistic that was significant beyond the .05 level (p = 0.000) (Table 13). This finding led to the rejection of the null hypothesis, $H_0$.

$H_0 = $ There is no significant difference in mean gain score in place value/regrouping between male and female students in grade three.

The comparison of the adjusted mean gain score in place value/regrouping of the male students with that of the female students was used to determine if either gender achieved significantly higher gains than the other. The adjusted mean gain score of the male students was 4.38. The adjusted mean gain score of the female students was 3.73 (Table 10). The ANCOVA yielded an F ratio of 1.298, a statistic that was not significant beyond the .05 level (p = 0.258) (Table 13). This finding led to the retention of the null hypothesis, $H_0$.

$H_0 = $ There is no significant difference in mean gain score in place value/regrouping between students in the experimental group and students in the control group in grade three.
The comparison of the adjusted mean gain score in place value/regrouping of the students in the experimental group with that of the students in the control group was used to determine if method of instruction resulted in significantly higher gains in achievement. The adjusted mean gain score of the experimental group was 4.59. The adjusted mean gain score of the control group was 3.51 (Table 13). The ANCOVA yielded an F ratio of 11.476, a statistic that was significant beyond the .05 level (p = 0.001) (Table 13). This finding led to the rejection of the null hypothesis, $H_0$.

Summary of Findings

The findings were reported in two sections to correspond to the two parts of the study. The first section reported findings related to the independent variables of gender, prior achievement and group acting on the dependent variable of mean gain score in mathematical measurement. The second section reported findings related to the same independent variables acting on the dependent variable of mean gain score in place value/regrouping. Separate findings for each grade level were reported in each section. The following summarizes these relationships.

1. Equality of groups was determined on the basis of measurement pretest scores between the experimental group and the control group, as well as between the males and females in grade one. Similar findings were determined in grades two and three.

2. The mean gain score in mathematical measurement of students
in both the experimental and control groups in grades one, two and three indicated overall growth in achievement.

3. No interaction was found among group, gender and prior achievement in mathematical measurement in grades one, two and three.

4. Students in grades one, two and three who were identified as low prior achievement scored significantly greater gains in measurement than students identified as high prior achievement, regardless of the method of instruction.

5. The control group's mean pretest score was significantly higher than that of the experimental group in place value/regrouping in grade one. In both grades two and three, the experimental group's mean pretest score was significantly higher than that of the control group. Therefore, in all grades the experimental and control groups were found to be unequal. Also, no significant difference in mean pretest scores was found between the males and females in grades one, two and three.

6. The mean gain score in place value/regrouping of students in both the experimental and the control groups in grades one, two and three indicated overall growth in achievement.

7. No interaction among group, gender and prior achievement in place value/regrouping in grade one could be determined due to an empty cell in the ANCOVA. No students in grade one in the experimental group received a pretest score that resulted in the high prior achievement classification.

8. No interaction was found among group, gender and prior achievement in place value/regrouping in grade two.

9. Interaction was found among group, gender and prior
achievement in adjusted mean gain scores for place value/regrouping in grade three. Students in the experimental group who were also classified low prior achievement received a significantly higher adjusted mean gain score than those students in the control group that were classified low prior achievement.

10. No significant differences in adjusted mean gain score in place value/regrouping between the experimental group and the control group were found in grades one and two.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine if mathematics instruction with journal writing resulted in a change (more or less) in achievement for primary students compared with mathematics instruction with no journal writing. One part of the study involved instruction in measurement, and the other part involved instruction in place value/regrouping. In each part, the mean gain score of the experimental group in each grade was compared to the respective mean gain score of the control group. Also of interest to this study was the interaction of gender and prior achievement to determine if the method of instruction was beneficial to a particular group.

The analysis of data provided the basis for several conclusions. Also, interviews of the experimental group teachers provided teachers' perceptions of the results of mathematics instruction with journal writing (see Appendix A).

Conclusions

The statistical analysis of Chapter 4 is the basis for the following conclusions:

1. The experimental group and the control group in grades one, two and three were not significantly different in their prior knowledge of mathematical measurement. This conclusion was made based on finding no significant difference in the pretest scores of these groups in each
grade level.

2. The males and the females in grades one, two and three were not significantly different in their prior knowledge of mathematical measurement. This conclusion was made based on finding no significant difference in the pretest scores of these groups in each grade level.

3. A significant difference in prior knowledge of mathematical measurement was found among the high, middle and low prior achievement groups in each grade level. This conclusion was expected since the groups were defined on the basis of pretest scores.

4. The experimental and control groups in each grade were significantly different in their prior knowledge of place value/regrouping. This conclusion was made based on finding significant differences in the pretest scores of these groups in each grade level. The control group in grade one had a much greater amount of prior knowledge in place value/regrouping than the experimental group. The experimental group in grades two and three had a greater amount of prior knowledge in place value/regrouping than the control groups in the respective grade levels.

5. The males and females in grades one, two and three were not significantly different in their prior knowledge of place value/regrouping. This conclusion was based on finding no significant difference in the pretest scores of these groups in each grade level.

6. Ten percent of the students in this study demonstrated much difference between prior knowledge of measurement and prior knowledge of place value/regrouping. These students' pretest scores in one topic identified them as high prior achievement, while their pretest scores
in the other topic identified them as low prior achievement.

7. Neither males nor females benefited more than the other gender from mathematics instruction in measurement and/or place value/regrouping regardless of the method of instruction and regardless of prior achievement. Male and female students achieved similar gains in measurement and in place value/regrouping. The similarity of the gains was not affected by method of instruction or by prior achievement in measurement. This confirmed the experimental group teachers' speculations that males and females did equally well in measurement and in place value/regrouping (see Appendix A).

Carpenter et al. (1976a) studied the results of the First National Mathematics Assessment. They reported similar results between primary grade level males and females in measurement, but not in place value/regrouping. Although they do not report significant differences in achievement, they do report that females scored slightly higher than males in place value/regrouping.

Tobias (1978) wrote about differences in math anxieties between males and females. In her conclusion that females have greater math anxieties than males, she implied that males' math achievement is greater than females. Tobias pointed to a lack of math confidence in females as the reason for the difference in achievement. Interestingly, experimental group teachers of second grade perceived that mathematics instruction with journal writing increased their students' confidence in using math skills (see Appendix A).

8. Journal writing did not result in significantly different mean gain scores in measurement in grades one, two and three.
Mathematics instruction with journal writing resulted in similar achievement gains in measurement as mathematics instruction with no journal writing for students in grades one, two and three. Also, no interaction occurred among the method of instruction, gender and prior achievement. This did not substantiate the perceptions of the experimental group teachers (see Appendix A).

Experimental group teachers and control group teachers did not speculate openly on which method of instruction produced the highest gain scores in measurement and place value/regrouping in this study. However, experimental group teachers provided insight into this during the interviews. They often referred to the way they provided instruction with no journal writing in the past, as they cited advantages to providing instruction with journal writing currently. The teachers' perceptions in each grade level implied that this method of instruction produced higher achievement gains in measurement and place value/regrouping.

The experimental group teachers reported many advantages of journal writing in math. They perceived greater parental involvement in the math the children were doing, increases in math and writing skills of the students and that it was easier for students to write about measurement than place value/regrouping. They also perceived that adjustments were made to instruction based on students' journal entries, but that more preparation time was required with this method of instruction.

Not all of the perceptions of the experimental group teachers were the same regarding mathematics instruction with journal writing.
First grade students were perceived as making growth in math and writing skills, whereas second grade students were reported to have grown in confidence in using these skills, and third grade students were reported to have become fluent in using these skills. Although the only skills perceived as increasing for first grade students were math and writing skills, second grade students were perceived as developing higher level thinking skills in math in the form of questioning, and third grade students were perceived as developing higher organizational skills as a result of journal writing.

9. Students in grade three with the least prior knowledge in place value/regrouping benefited the most from mathematics instruction with journal writing. Mathematics instruction with journal writing resulted in significant differences in mean gain scores in place value/regrouping for some students in grade three, but no significant differences were found in grades one and two. In grades one and two, no interaction was found among group, gender and prior achievement, and the control group made the same achievement gains as the experimental group. As in the section directly above, the perceptions of the experimental group teachers were not substantiated by the data (see Appendix A).

However, in grade three interaction occurred between group and prior achievement. Low prior achievement students in the experimental group scored significantly higher gains than low prior achievement students in the control group. This substantiated some of the perceptions of the experimental group teachers.

Experimental group teachers perceived that the low students in
third grade gained more in achievement for both topics than their classmates. Although the teachers did not make a direct comparison with the control group, their perception was that math instruction with journal writing produced higher achievement. This speculation was based on a comparison of present and past experiences with both methods of instruction.

The results of this study appeared to support findings of an earlier study by Ferguson and Fairburn (1984). In a study of second grade students, they reported significant gains in mathematics achievement with low prior achievement students when mathematics instruction included student-centered writing. However, their study did not identify any specific topics of mathematics instruction, nor any specific type of student-centered writing.

The results of this study agreed with the results of a previous study by Evans (1984). Although the study was not conducted on primary students, her study reported higher gain scores of students that received mathematics instruction with journal writing. Using her own class and another intact group, she indicated that her students were lower in prior achievement than the other students. Therefore, she concluded that mathematics instruction with journal writing resulted in higher gain scores than mathematics instruction with no journal writing for students in sixth grade.

10. The gap in prior knowledge of measurement and place value/regrouping decreased between the high and low groups in each grade level. This conclusion was based on a general trend of the low
prior achievement group achieving greater gains than the high group in most instances, with significantly higher gains occurring for the low group in grade three in place value/regrouping. No specific reason for this decrease in achievement gap could be determined from the analysis of data.

**Recommendations for Instruction**

Results of this study have contributed to the literature on student-centered writing and to the literature on mathematics instruction. Studies that investigated the results of mathematics instruction incorporating student-centered writing in primary school were nearly non-existent. The results of this study provided unique data used to draw conclusions that were considered in making the following recommendations for instruction:

1. It is recommended that primary school teachers incorporate journal writing in mathematics instruction for low-achieving students. This recommendation is directed with more emphasis to teachers of grade three students when teaching place value/regrouping, since low third grade students made the greatest achievement gains in place value/regrouping when they wrote in daily math journals during mathematics instruction.

   This recommendation is strengthened by the fact that students who wrote in daily math journals during mathematics instruction actually received less direct mathematics instruction due to the fact that approximately fifteen minutes of each class was devoted to journal
writing. Students in the control group received direct mathematics instruction for the full math time period.

2. Primary school teachers need to pretest each mathematical topic of study. Since ten percent of the students in this study scored in the high prior achievement range in one topic while scoring in the low prior achievement range in the other topic, teachers would need to determine this prior to making instructional decisions regarding grouping and/or content. Also, since the gap in achievement between high and low prior achievement groups in this study decreased for primary students in the measurement and place value/regrouping, the possibility exists that a lesser need exists for grouping students based on achievement in the intermediate grade levels.

3. It is recommended that primary teachers exercise caution against predetermined views about students' prior knowledge in mathematical topics based on gender differences. Although opinions of gender differences can be found in the literature, this study supports the literature reporting no math differences based on gender.

4. Primary school teachers should consider the perceptions of the teachers as outlined in Appendix A. Although these perceptions were not a direct part of the statistical analyses in this study, they are worthy of consideration. The teachers that provided mathematics instruction with journal writing perceived many advantages based on their past experiences providing mathematics instruction with no journal writing. They perceived advantages both in math skills, writing skills and thinking skills for students in grades one, two and three.
Recommendations for Further Research

1. Higher level interactions in place value/regrouping in first grade were suppressed due to an empty cell in the 3-way ANOVA. Further research should increase the number of students at all levels to decrease the possibility of empty cells.

2. Achievement gains were realized in measurement and place value/regrouping using both methods of instruction in grades one, two and three. Further research should determine if any significant differences occur in the retention of these gains over a longer period of time.

3. It is recommended that further research be done with intermediate students to investigate the relationship of journal writing in math instruction. A significant difference in achievement gains was found in third grade between low achieving students that wrote in journals as a part of mathematics instruction compared with low achieving students that did not write in journals during math instruction. No significant difference in achievement gains was found in grades one and two. Further research could provide data to determine if low achieving intermediate students also score greater gains by writing in daily math journals.

4. This study included different pretests and posttests in measurement and place value/regrouping at each grade level. This allowed for analyses of data within each grade level. Each test was based on only the specific content of each grade level. Further research should utilize one pretest and one posttest that would assess
the maximum content range spanning from at least two grade levels above and below the students being tested.

5. It was not within the scope of this study to assess differences in attitudes of teachers and/or students on each method of instruction. Further research should determine if any differences in attitude occur as a result of the method of instruction. Also, statistical analyses could be applied in another study to measure many of the teacher perceptions listed in Appendix A.

6. The conclusions of this study were limited to the students in Bozeman, Montana that participated in the experimental and control groups. Further research is recommended to investigate the problem of this study on students in other areas of Montana and/or other states.
SELECTED BIBLIOGRAPHY
SELECTED BIBLIOGRAPHY


Ferguson, Anne M. and Jo Fairburn. "Language Experience for Problem Solving in Mathematics." Reading Teacher 38, No. 6 (Feb. 1985): 504-507.


Friedman, Sheila. "If You Don't Know How to Write, You Try: Techniques That Work in First Grade." The Reading Teacher (Feb. 1985): 516-521.


APPENDIX A

TEACHER INTERVIEWS ON JOURNAL WRITING IN MATH
SUMMARY OF TEACHER INTERVIEWS ON JOURNAL WRITING AS AN INTEGRAL PART OF MATHEMATICS INSTRUCTION

Each teacher in the experimental group was interviewed following the completion of the unit on place value/regrouping, which came after the unit on measurement. They were each asked eleven questions in the order in which they appear below. The actual responses were quite lengthy since they were given in a conversational format. The responses have been condensed here in a list format for summarizing purposes, although the terminology used is that of the teachers.

Question #1: What did your students gain from math instruction with journal writing that you would attribute directly to the journal writing component?

Grade 1 - great deal of involvement with their parents
- growth in language arts skills
- growth in mathematics skills

Grade 2 - confidence in math skills
- confidence in writing skills
- development of a higher level of questioning in class

Grade 3 - fluency in thinking skills
- fluency in writing skills
- increased vocabulary skills in math
- increased skills in expression
- organizational skills in learning math

Question #2: What adjustments did you make in your instruction after reading the daily math journals?

Grade 1 - adjustments to fulfill their predictions when possible
- adjustments to fulfill what they wanted to learn
- now am giving pretests and posttests for every unit

Grade 2 - approach lessons much differently now
- more lessons geared toward student-centered writing
- learned individual difficulties from reading journals
- adjust lessons to zero in on those difficulties in math
- teach toward specific writing difficulties observed
- used the manipulatives they wrote about
- managed my time better in lessons for all subjects
- made my teaching more consistent and solid
- give less handouts and worksheets
- increased doing things kids could write about
- had conferences with each student after reading journal
- emphasized conceptual learning rather than mechanical
Grade 3 - instructed toward confusion indicated in math journals
- much better teaching toward learning styles of kids
- adjusted teaching to facilitate student writing
- pinpointed specific areas of help for individuals
- presented lessons more thoroughly and conceptually
- became a better "model" for my students
- helped make me a better teacher

Question #3: What would you consider the single most important advantage that you would like to tell other teachers?

Grade 1 - tremendous increase in parent involvement and support in math with their children (also in writing skills)
Grade 2 - the improvement in teaching in both writing and math that takes place from being able to better focus on specific weaknesses
Grade 3 - the improvement in my teaching, including a better variety of presentations which produced much better conceptual understanding by students (especially in place value/regrouping)

Question #4: What problems did incorporating math journals into math instruction have for the students?

Grade 1 - a writing problem early in the year, but it decreased
- process entries wore out (not all lessons fit process)
Grade 2 - gap occurred sometimes (when they couldn't do the math they found it difficult to write about it)
- occasional lack of ability to express
Grade 3 - journal writing time was too concentrated (every day every week was sometimes tedious for students)
- took longer time for some students to write entries

Question #5: What problems did it have for you, the teacher?

Grade 1 - time (to come up with topics)
Grade 2 - takes much more time (but, it is "quality" time)
Grade 3 - time it takes
- hard for an substitute teacher not trained in this
Question #6: What insights did you gain from the parent involvement once a week reading the journals and writing an entry?

Grade 1 - they loved it and want it to continue
- some found it was hard to write an entry
- need specific questions to answer in journals
- some said it was hard to find the time to do this
- gave them ideas to work on at home with child

Grade 2 - parent interest made math more meaningful to children
- children's entries appeared to ask for parent approval
- provided many with one-to-one tutoring at home
- increased self-esteem of many children
- increased motivation for math (now say math is favorite)
- surprised me to learn that several parents didn't bother
- not all parents are interested (disappointing)

Grade 3 - not all parents had good response
- most parents were very favorable and appreciative
- most parents communicated well to children
- kids whose parents participated showed the most enthusiasm for math
- extremely important to the kids
- some parents were to critical
- added to learning as parents shared their learning
- will plan more togetherness with parents next year

Question #7: What areas other than math did journal writing carry over into voluntarily by the students?

Grade 1 - interrelated skills, but nothing specific
- parents said journal writing had been observed in play

Grade 2 - the ability to move ahead alone when stumped ✓
- increased amount of writing in all areas
- predictions carried over
- more prone to focus in on writing topic now
- increase in vocabulary
- organization of thinking in other areas

Grade 3 - in reading the kids predicted much more
- none specifically

Question #8: Did you notice any differences in ability to write about measurement compared with place value/regrouping?

Grade 1 - measurement was easier since it was more tangible
- games in place value/regrouping was somewhat easier
- about equal
Grade 2 - measurement was easier since it dealt with concreteness
- place value/regrouping required more perspective
- place value/regrouping took longer to internalize

Grade 3 - neither was harder for them
- wrote much more about measurement
- did better on place value/regrouping due to it last

Question #9: What specific journal entries were the most beneficial for students?

Grade 1 - predictions (they loved it)
- story-problems
- reflection entries are hard for them

Grade 2 - prediction showed the best growth
- feeling was the easiest and liked best
- story-problems were second easiest
- summary entries were confused with process sometimes
- process and reflection were not beneficial
- process was hardest but was the most beneficial
- prediction was their favorite
- feelings entered into many other entries
- summary entries seemed to bore them
- story-problems hard but showed much improvement

Grade 3 - process is the most beneficial but the hardest
- feelings expressed well (kids said helped them learn)
- liked to do prediction and reflection
- summary was beneficial for teacher to read
- like story-problems (enjoyed sharing these)
- summary was easy for them (did not bore them)

Question #10: What recommendations would you make for future use of journal writing as a part of mathematics instruction?

Grade 1 - continue with parent participation once a week
- ask specific questions for parents to write about
- less emphasis with specific entries (schedule)
- relate more to real-life situations
- have individual conferences with students about journals

Grade 2 - schedule is needed to guarantee use of all entries (forces teachers and students to expand)
- use a pre-made journal for each to write in
- don’t write every day (perhaps 3 days a week)
- inservice program using experienced teachers
- total commitment by all teachers ("explode" in district)
- learn the pitfalls to avoid them
Grade 3 - do process entries on new concepts mainly
- not every day (two to three times a week)
- journals should be looseleaf notebook (one page per day)
- have a separate parent entry page (colored page)
- put journals aside occasionally to prevent burnout
- an excellent inservice project (use experienced to help)
- continue to use journals in math

Question #11: In your perception, which students gained the most in mathematics achievement among the high, middle or low groups and between the males and females?

Grade 1 - low group (journals revealed most to me, the teacher)
- middle group probably gained the most overall
- no difference in gender (but, more male parents wrote in journals than did female parents)

Grade 2 - middle group (especially in writing)
- low group would grow the most
- no difference in gender

Grade 3 - low group (could get to them better)
- don't know about any gender differences (probably none)
- boys probably gained the most
APPENDIX B

TEST INSTRUMENTS FOR MEASUREMENT
First Grade Measurement Pre-test

NAME ___________________________ GRADE ______ SCORE ______

1. Place an X on the LONG straw.

2. Place an X on the SHORT straw.

3. Which pencil is SHORTER than your new crayon. Mark an X.

4. Which pencil is LONGER than your new crayon. Mark an X.

5. Use your new crayon. How long is this object?

6. Use your new crayon. How long is this object?

7. Use your inch ruler. How long is this object?

8. Use your inch ruler. How long is this object?
9. Use your centimeter ruler. How long is this object?

   ABOUT ________ CENTIMETERS

10. Use your centimeter ruler. How long is this object?

   ABOUT ________ CENTIMETERS

11. 2 pints equal 1 quart. How many containers can you fill?

   USE YOUR INCH RULER. MEASURE THE LENGTH OF EACH SIDE.

12. 2 pints equal 1 quart. How many containers can you fill?

   USE YOUR INCH RULER. MEASURE THE LENGTH OF EACH SIDE.

<table>
<thead>
<tr>
<th>SIDE</th>
<th>INCHES</th>
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<tbody>
<tr>
<td>A</td>
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<td>B</td>
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<td>C</td>
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</table>
First Grade Measurement Posttest

NAME ______________________ GRADE 1  SCORE _____

1. Which pencil is longer than your new crayon. Mark an X.

2. Use your new crayon. How long is this object?

3. Use your new crayon. How long is this object?

4. Which pencil is shorter than your new crayon. Mark an X.

5. 2 pints equal 1 quart. How many containers can you fill?

   pints _______ quarts _______ quarts _______

6. Use your centimeter ruler. How long is this object?

   ABOUT ______ CENTIMETERS

7. Use your centimeter ruler. How long is this object?

   ABOUT ______ CENTIMETERS
Use your inch ruler. Measure the length of each side.

<table>
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<td>B</td>
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<td>C</td>
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</tbody>
</table>

11. Use your inch ruler. How long is this object?
   ABOUT __ INCHES

12. Use your inch ruler. How long is this object?
   ABOUT __ INCHES

13. 2 pints equal 1 quart. How many containers can you fill?

   pints  pints  quarts  quarts

14. Place an X on the LONG straw.

15. Place an X on the SHORT straw.
Second Grade Measurement Pre-test

NAME ________________________________________________

1. Place an X on the longest object below.

Measure the length of each object below. Use your centimeter ruler.

2. about _____ centimeters

3. about _____ centimeters

Measure the length of each side below. Use your centimeter ruler.

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<td>a</td>
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<tr>
<td>d</td>
<td>centimeters</td>
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</table>

4. 2 pints equal 1 quart. How many containers can you fill? Color them.

5. 2 pints equal 1 quart. How many containers can you fill? Color them.

<table>
<thead>
<tr>
<th>pints</th>
<th>quarts</th>
<th>quarts</th>
<th>quarts</th>
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</table>

6. 2 pints equal 1 quart. 4 pints equal _____ quarts

7. 2 pints equal 1 quart. 6 pints equal _____ quarts
12. 1 quart equals 2 pints. How many containers can you fill? Color them.

\[ \boxed{\text{quarts}} \]
\[ \boxed{\text{pints}} \]
\[ \boxed{\text{pints}} \]
\[ \boxed{\text{pints}} \]

13. 1 quart equals 2 pints. 3 quarts equals _____ pints

(What time is it?)

14.

15.

16.

17.

18.

19.

20. Give the length of the segment to the nearest inch.
Second Grade Measurement Posttest

NAME ___________________________ GRADE 2 SCORE ____________

1. Give the length of the segment to the nearest inch.

2. 2 pints equal 1 quart. How many containers can you fill? Color them.

3. 1 quart equals 2 pints. 3 quarts equals _______ pints

4. 2 pints equal 1 quart. How many containers can you fill? Color them.

5. 2 pints equal 1 quart. 6 pints equal ______ quarts

6. 2 pints equal 1 quart. 4 pints equal ______ quarts

7. 1 quart equals 2 pints. How many containers can you fill? Color them.

Measure the length of each object below. Use your centimeter ruler.

8. ___________ about _______ centimeters

9. ___________ about _______ centimeters
Measure the length of each side below. Use your centimeter ruler.

<table>
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<th>side</th>
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<td>centimeters</td>
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<td>d</td>
<td>centimeters</td>
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</table>

20. Place an X on the longest object below.
Third Grade Measurement Pre-test

NAME ____________________________________________  GRADE 3  SCORE __________

1. Measure the straw in inches. Use the inch ruler below the straw. 1.________

2. Give the length of the segment to the nearest inch. 2.________

3. Give the length of the segment to the nearest inch. 3.________

4. Give the length of the segment to the nearest half-inch. 4.________

5. Give the length of the segment to the nearest half-inch. 5.________

6. Write the time shown on the clocks. 6.________

7. ________

8. 2 cups equal 1 quart. 6 cups equal ______ quarts. 8.________

9. 2 pints equal 1 quart. 4 pints equal ______ quarts. 9.________
10. Give the length of the segment to the nearest centimeter.

11. Give the length of the segment to the nearest centimeter.

Find the perimeter of each figure.

12. 

13. 

Write the time shown on the clocks.

14. 

15. 

Would you use inches or feet to measure these?

16. Length of a room

17. Height of a milk carton

Would you use centimeters or meters to measure these?

18. Length of your nose

19. Length of a football field
(Write the time shown on each clock.)

20.  

21.  

22.  

(Which of the following means quarter to 4?)

23.  4:15  4:30  4:45  

(Which of the following means quarter past 4?)

24.  3:15  3:30  3:45  

25.  4 quarts equal 1 gallon

12 quarts equal ____ gallons.

26.  4 quarts equal 1 gallon.

2 gallons equal ____ quarts.
Third Grade Measurement Posttest

(Write the time shown on each clock.)

1. [Clock 1]
2. [Clock 2]
3. [Clock 3]

4. Give the length of the segment to the nearest centimeter.
5. Give the length of the segment to the nearest centimeter.

(Would you use centimeters or meters to measure these?)

6. Length of your nose
7. Length of a football field
8. Give the length of the segment to the nearest inch.

9. 2 pints equal 1 quart. 4 pints equal _____ quarts.
Name_________________________ Grade 3 Page 2

10. Write the time shown on the clocks.
   10. ________
11. ________

12. Measure the straw in inches. Use the inch ruler below the straw. 12. ________

13. Give the length of the segment to the nearest inch.
   13. ________

14. 4 quarts equal 1 gallon.
    2 gallons equal ______ quarts.
    14. ________

15. Write the time shown on the clocks.
   15. ________
16. ________

17. 4 quarts equal 1 gallon
    12 quarts equal ______ gallons. 17. ________
18.  3:15  3:30  3:45

19.  4:15  4:30  4:45

20. Give the length of the segment to the nearest half-inch.

21. Length of a room

22. Height of a milk carton

23. Give the length of the segment to the nearest half-inch.

24. 2 cups equal 1 quart.  6 cups equal _____ quarts.

25.  [Diagram of a triangle with sides labeled 4 centimeters and 4 centimeters, with a question mark indicating the unknown side]

26.  [Diagram of a square with sides labeled 5 centimeters, with a question mark indicating the perimeter]
APPENDIX C

TEST INSTRUMENTS FOR PLACE VALUE/REGROUPING
First Grade Place Value/Regrouping Pre-test

NAME ______________________________________ GRADE 1 ____________________________________ PRE-Score ____

1. USE YOUR INCH RULER. HOW LONG IS THIS OBJECT?

______________________________________________________

ABOUT _______ INCHES

2. USE YOUR INCH RULER. HOW LONG IS THIS OBJECT?

______________________________________________________

ABOUT _______ INCHES

3. USE YOUR CENTIMETER RULER. HOW LONG IS THIS LINE?

______________________________________________________

ABOUT _______ CENTIMETERS

4. USE YOUR CENTIMETER RULER. MEASURE THE LENGTH OF THIS LINE.

______________________________________________________

ABOUT _______ CENTIMETERS

5. 2 PINTS EQUAL 1 QUART. HOW MANY CONTAINERS CAN YOU FILL?

____ PINTS __ QUARTS

6. CIRCLE EACH GROUP OF TEN. HOW MANY TENS ARE THERE?

____ TENS

7. WRITE THE NUMBER OF TENS, AND WRITE THE TOTAL ALTOGETHER.

____ TENS

____ TOTAL

8. CIRCLE ANOTHER NAME FOR THE NUMBER IN THE BOX.

2 tens 8 ones

8 tens 2 ones
First Grade Place Value/Regrouping Pre-test - Page 2

9. HOW MANY OBJECTS ARE THERE?

10. CIRCLE ANOTHER NAME FOR THE NUMBER IN THE BOX.

11. HOW MANY OBJECTS ARE THERE?

12. HOW MANY OBJECTS ARE THERE?

FIND THE SUMS.

13. 5 + 3 14. 6 +5 15. 16 + 5 16. 38 +34 17. 69 + 85 18. 467 + 234 19. 154 +384

20. WRITE THE NUMBER OF TENS, AND WRITE THE TOTAL ALTOGETHER.
First Grade Place Value/Regrouping Posttest

NAME ___________________________ GRADE ___ SCORE ______

1. USE YOUR INCH RULER. HOW LONG IS THIS OBJECT?

ABOUT _______ INCHES

2. HOW MANY OBJECTS ARE THERE?

TENS ONES

3. CIRCLE ANOTHER NAME FOR THE NUMBER IN THE BOX.

2 tens 8 ones

8 tens 2 ones

4. CIRCLE EACH GROUP OF TEN. HOW MANY TENS ARE THERE?

TENS

FIND THE SUMS.

5. 5 + 3 6 + 4 7 + 5 8 + 34 9 + 85 10 + 234 11 + 384

6. 6 + 5 7 + 5 8 + 34 9 + 85 10 + 234 11 + 384

9. 69 + 34 10. 467 + 234 11. 154 + 384

12. WRITE THE NUMBER OF TENS, AND WRITE THE TOTAL ALTOGETHER.

TENS

TOTAL
13. WRITE THE NUMBER OF TENS, AND WRITE THE TOTAL ALTOGETHER.

14. USE YOUR INCH RULER. HOW LONG IS THIS OBJECT?

15. HOW MANY OBJECTS ARE THERE?

16. CIRCLE ANOTHER NAME FOR THE NUMBER IN THE BOX.

17. USE YOUR CENTIMETER RULER. MEASURE THE LENGTH OF THIS LINE.

18. HOW MANY OBJECTS ARE THERE?

19. 2 PINTS EQUAL 1 QUART. HOW MANY CONTAINERS CAN YOU FILL?

20. USE YOUR CENTIMETER RULER. HOW LONG IS THIS LINE?
Second Grade Place Value/Regrouping Pre-test

NAME ___________________________ GRADE 2 PRE-SCORE ________

1. USE YOUR INCH RULER. HOW LONG IS THIS LINE?
   ___________________________ INCHES

2. USE YOUR INCH RULER. HOW LONG IS THIS LINE?
   ___________________________ INCHES

3. 1 QUART = 2 PINTS. HOW MANY CONTAINERS CAN YOU FILL? COLOR THEM.

   QUARTS
   ___________________________

   PINTS
   ___________________________

4. WHAT TIME IS IT? 5.
   ___________________________

   ___________________________

5. WHAT TIME IS IT?

6. CIRCLE EACH GROUP OF TEN. HOW MANY OBJECTS ARE THERE?

   TENS ONES

7. HOW MANY OBJECTS ARE THERE?

   TENS ONES

8. WHICH NUMBER IS IN THE TENS PLACE IN THE NUMBER 42? ________
9. **Circle another name for the number in the box.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Tens</th>
<th>Ones</th>
</tr>
</thead>
<tbody>
<tr>
<td>84</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

10. **Tens Ones**

<table>
<thead>
<tr>
<th>10.</th>
<th>5</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11.</th>
<th>4</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

12. 6 +8

13. 9 + 4 =

14. 16 + 5

15. 22 - 8

16. 32 + 46

17. 467 + 234

18. 249 + 163

19. 8 - 3

20. 19 - 6

21. 44 - 17

22. 76 + 68

23. 6 + 39

24. 38 + 24

25. 69 + 21
Second Grade Place Value/Regrouping Posttest

NAME ___________________________ GRADE ___________ 

1. USE YOUR INCH RULER. HOW LONG IS THIS LINE?

______________________________ INCHES

2. 6 + 8
3. \(9 + 4 = \)
4. TENS ONES
   \(4 \) \(7\)
   \(+ 4 \) \(3\)
5. \(467\)
6. \(249\)
7. CIRCLE EACH GROUP OF TEN. HOW MANY OBJECTS ARE THERE?

\(\) TENS \(\) ONES

8. \(8\)
9. \(19\)
10. \(44\)
11. \(76\)
12. WHAT TIME IS IT?

13. TENS ONES
   \(5 \)
   \(3\)
   \(+ 2 \)

14. WHICH NUMBER IS IN THE TENS PLACE IN THE NUMBER 42?
22. CIRCLE ANOTHER NAME FOR THE NUMBER IN THE BOX.

8 tens 4 ones
4 tens 8 ones

23. USE YOUR INCH RULER. HOW LONG IS THIS LINE? INCHES

24. HOW MANY OBJECTS ARE THERE?

TENS ONES

25. 1 QUART = 2 PINTS. HOW MANY CONTAINERS CAN YOU FILL? COLOR THEM.

QUARTS PINTS
Third Grade Place Value/Regrouping Pre-test

NAME ___________________________________ GRADE 3 SCORE __

1. Use your inch ruler. Measure the line to the nearest inch.

   ____________________________ INCHES ____________________________

2.  456  3.  8429  4.  6000  5.  472  6.  12

   + 56   - 43   -3005   +811   12

   ____________________________

7. 1 gallon equals 4 quarts. 4 gallons equals ________ quarts.

8. Circle the time below that means quarter to six.
   6:15  6:30  5:45  6:45

9. 3 hundreds 7 tens 6 ones = ______ hundreds 17 tens 6 ones

10. 54  11. 860  12. 514  13. 245  14. 300  15. 5840

    96  -473  -131  -146  -185  -3037

    ____________________________

16. 2 hundreds 4 tens 3 ones = 2 hundreds 3 tens ______ ones

17. What time is it?  18. What time is it?

   ____________________________


    +124  +526  +96  +367  +2845  -66

    ____________________________

25. Use your inch ruler. Measure the line to the nearest half-inch.

   ____________________________
Third Grade Place Value/Regrouping Posttest

NAME____________________________________________________ GRADE 3 PRE-SCORE_____

1. Use your inch ruler. Measure the line to the nearest inch.

2. Use your inch ruler. Measure the line to the nearest half-inch.

3. What time is it?

4. What time is it?

5. 1 gallon equals 4 quarts. 4 gallons equals ______ quarts.

6. Circle the time below that means quarter to six.
   6:15  6:30  5:45  6:45
      +124     +526     + 96     +367    +2845    -66

   13. 54      14. 860     15. 514    16. 245    17. 300     18. 5840
       +33      -473    -131     -146    -185     -3037

19. 2 hundreds 4 tens 3 ones = 2 hundreds 3 tens ______ ones

20. 3 hundreds 7 tens 6 ones = ______ hundreds 17 tens 6 ones

21. 456      22. 8429    23. 6000    24. 472    25. 32
    + 56     - 43      -3005      +811    +12

   45
   +22