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

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 grpup.

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

Garmi Ray Wells, I

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of the requirements for the degree

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APPROVAL

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Carmi Ray Wells, I

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Signature Carmi L. Wells, I

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.

VITA

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.

Mr. Wells was a teacher for eight years in elementary, junior high, and secondary school grades in New York, Louisiana, and Montana. He also was a school principal for seven years in Colorado, Maine and Montana. He has taught Reading and Language Arts in the School of Education, Northern Montana College, Havre, Montana, where he has recently accepted the position of Assistant Dean of Education.

Mr. Wells holds membership in Phi Delta Kappa, Bozeman Chapter. He also is a member of the National Education Association, International Reading Association and Montana State Reading Council. He is a active Kiwanian and a past Rotarian.

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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ABSTRACT

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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.

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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 <u>Arithmetic</u>

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.

Algorithm. A symbolic representation of an operation in a step-by-step procedure for assigning another number [that is, sum, quotient, product] (Shepherd and Ragan, 1982 p. 306).

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.

   c. Review of the Second National Mathematics Assessment.

   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 <u>State Course of Study</u> 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 measuremnent 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.

Literature Related to Place Value/Regrouping

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:

```
 5547      5547      5547      5547
+ 394     + 394     + 394     + 394
 ----      ----      ----      ----
 5         58        593       5941
```

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:

```
 5547      5547
+ 394     + 394
 ----      ----
 58        5941
 593
 5941
```

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 Reys 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:

63	--->	6 tens 3 ones	--->	5 tens 13 ones (renamed)	
-47	--->	-4 tens 7 ones	--->	-4 tens 7 ones	
				1 ten 6 ones	---------> = 16

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

63	--->	6 tens 3 ones	--->	6 tens 13 ones (added 10 ones)	
-47	--->	-4 tens 7 ones	--->	-5 tens 7 ones (added 1 ten)	
				1 ten 6 ones	---------> = 16

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 Assesssment 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 conversion exercise involving the conversion of inches to feet, with similar results on conversions such as pints and quarts.

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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 value/regrouping.

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 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 assesssments 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 provided 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