5-1999

The relationship of cognitive learning styles, mathematics attitude, and achievement in a problem posing classroom

Mary Ellen Owens

To the Graduate Council:

I am submitting herewith a dissertation written by Mary Ellen Owens entitled "The relationship of cognitive learning styles, mathematics attitude, and achievement in a problem posing classroom." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

John R. Ray, Major Professor

We have read this dissertation and recommend its acceptance:

Russell L. French, George W. Harris Jr., H. T. Mathews

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Mary Ellen Owens entitled "The Relationships of Cognitive Learning Styles, Mathematics Attitudes, and Achievement in a Problem Posing Classroom." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Dr. John R. Ray, Major Professor

We have read this dissertation
and recommend its acceptance:

Russell L. French

Dr. Russell L. French

Dr. George W. Harris, Jr.

H T Mathews

Dr. H. T. Mathews

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

The Relationships of Cognitive Learning Styles, Mathematics Attitude, and Achievement in a Problem Posing Classroom

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Mary Ellen Owens

May 1999

DEDICATION

This dissertation is dedicated to my

husband, Stephen Owens and our children

Mary Ellen and Todd

ACKNOWLEDGEMENTS

I wish to thank the many faculty members at the University of Tennessee who have helped me with this dissertation. I am especially thankful to Dr. John R. Ray, the chairperson of my committee, for his continued support and guidance. I want to express my sincere appreciation to Dr. George W. Harris, Jr., Dr. Russell L. French, and Dr. H. T. Mathews who served as members of my doctoral committee and whose combined efforts made this all possible. I also wish to thank Cary Springer in the Statistics Department for her helpful assistance.

I wish to acknowledge the support and help of the administration, faculty, and staff of Walters State Community College. I especially wish to thank Dr. Judith Hector and all my friends in the Mathematics Department. Their support and encouragement has meant a great deal to me.

I wish to thank my family for their constant encouragement and support. I am especially grateful to my husband, Stephen, for his assistance and ability to impart calmness whenever I needed it. I wish to thank my daughter who made it fun. I especially wish to thank my Aunt Mary who gave me this dream when I was a child.

ABSTRACT

This study investigated relationships of cognitive learning styles, mathematics attitude, and mathematics achievement for students instructed with problem posing activities. It was conducted with pre-algebra students at Walters State Community College in Morristown, Tennessee. For one semester, three control classes (45 students) were taught in a traditional manner; and three treatment classes (46 students) were taught in a traditional manner plus one-third of the class time devoted to problem posing activities. Hypothesis one claimed there would be no significant difference in the mathematics achievement of control versus treatment students based on learning style and initial mathematics attitude. Hypothesis two claimed there would be no significant difference in attitude change during the study for students in the control versus treatment groups.

Pre-tests and post-tests of mathematics achievement, using the final examination of the course, and mathematics attitudes, using Fennema-Sherman Mathematics Attitudes Scales, were given. Learning styles were evaluated with Kolb's Learning-Style Inventory (LSI-IIa). Due to the low number of converger learners, students were grouped for analyses in two ways: 1) concrete experience versus abstract conceptualization learners and 2) reflective observational versus active experimentation learners.

Achievement gain, for hypothesis one, was analyzed by ANOVA with factors of learning style and treatment group membership; pre-attitude was tested as a covariate.

Abstract conceptualization learners in the treatment group showed a significantly lower achievement gain than did abstract learners in the control group. No significant difference in achievement gain was seen between concrete learners in control and treatment groups. Mathematics pre-attitudes of students showed no significant effect on mathematics achievement gain. Analysis of students as reflective observational versus active experimentation learners showed no interactions.

Changes in mathematics attitudes were analyzed by repeated measures ANOVA with factors of learning style and treatment group membership; attitude tests were repeated over time. For attitude domains of anxiety and confidence in doing mathematics, abstract learners in the treatment group showed significantly lower attitude improvements than abstract learners in the control group. Abstract learners in general found mathematics more useful than did concrete learners.

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Overview

Today's community college students seeking either employment or further academic opportunities require a greater understanding of mathematics, improved problem solving performance, and increased ability to communicate self-generated ideas (Prichard, 1995). To achieve these goals, a change in instructional approach from traditional, behaviorist methodology to constructivist methodology is advocated by both the National Council of Teachers of Mathematics (NCTM), (1991) and the American Mathematical Association of Two-Year Colleges (AMATYC), (1995). The constructivist learning theory asserts that knowledge cannot be directly transmitted by an instructor. A student must develop his own understandings through an active process of assimilation and accommodation of ideas (Gadanidis, 1994).

The American Mathematical Association of Two-Year Colleges supports constructivism wherein it calls for decreased rote application and memorization of formulas, reduced drill and practice exercises, and elimination of word problems which are unrelated to daily life. Reformed classrooms are to show active student involvement, open-ended and realistic adult problems, mathematical reasoning, problem solving tasks, and oral and written communication of mathematics (AMATYC, 1995). To meet these proposals, the community college mathematics student is quite likely to require different, more creative measures of instruction (Prichard, 1995).

Community college classes may be composed of diverse populations. Classes may consist of students of varying ages, attitudes, educational interests, and work backgrounds. However, one commonality among community college mathematics departments is the need of over fifty percent of enrollees to receive remedial or foundation level instruction (AMATYC, 1995).

Need For the Study

As the community college mathematics teacher strives to apply constructivist instruction within his teaching format, problem posing lessons are encountered as one possibility. In the *Curriculum and Evaluation Standards for School Mathematics*, the National Council of Teachers of Mathematics refers to problem posing as "an activity that is at the heart of doing mathematics" (NCTM, 1989). In the *Professional Standards for Teaching Mathematics* (NCTM, 1991), the instructor is asked to model and emphasize aspects of problem solving that include formulating and posing problems. Problem solving instruction is to involve more than solving textbook problems; students are to generate problems from given situations and to create new problems by modifying existing ones. Students are to develop a conceptual understanding of material being studied through application of Polya's "looking back" step (Polya, 1957) and Brown and Walter's "What-if?" and "What-if-not?" questions (Brown & Walter, 1983).

Although problem posing sounds like a reasonable teaching strategy, little is known about either the cognitive processing or affective issues involved in its use (Kilpatrick, 1987). Journal articles describing lessons based on problem posing activities are not uncommon (Axelson, 1992; Bush & Fiala, 1986; Friel & Gannon, 1995; Lopez-Real, 1995; O'Connell, 1995; Silver & Adams, 1987; Silverman, Winograd, & Strohauer, 1992); other writings discussing problem posing theory and educational basis also exist (Brown & Walter, 1993; Moses, Bjork, & Goldenberg, 1990; Silver, 1994). However, almost no systematic research on classroom application of problem posing instruction exists (Dillon, 1988; Silver, 1994).

Based on the theory that learning is influenced by the student's cognitive learning style and attitude toward a subject (English & Halford, 1995), mathematics educators need to examine relationships between problem posing instruction, student cognitive learning style, and student attitude toward mathematics. If the diverse population of the community college mathematics class is to be instructed with problem posing lessons, there is a need to learn what outcomes may be expected.

Problem

Previous research involving problem posing has investigated its influence on groups of students, but not its influence on students as individuals with particular learning characteristics and needs. Problem posing is theorized by Silver (1994), Balka (1974), and Getzels (1975) as being a divergent, creative thought activity. Perhaps students with differing creativity levels or learning styles respond to problem posing differently. Could problem posing instruction function well for some students, but not well for others?

Ellerton (1986) and Leung (1993) stated that problem posers, with higher achievement ratings, outperformed those with lower achievement ratings. Lower achievers found problem posing difficult. Since most remedial or foundation level mathematics students have achievement difficulties, could problem posing be a difficult or frustrating task for this population of students?

Silver (1994) stated that research does not discuss instances wherein students reject or react negatively to problem posing, however, he speculated that such cases must exist because students are known to react differently to instances of higher levels of uncertainty. Community college remedial mathematics teachers, who are seeking constructivist instruction through problem posing lessons, need to be aware of its potential results. The primary problem of this study was to study the relationships, if any, between student learning style, mathematics attitude, and mathematics achievement gain for remedial, community college students in a classroom employing problem posing instruction.

PURPOSE

The purpose of this study was to obtain information which would guide instructors in the appropriate use of problem posing instruction with remedial algebra, community college students. Areas studied focused on student cognitive learning styles as described by Kolb's Learning Style Inventory, mathematics attitudes as determined by Fennema-Sherman Mathematics Attitude Scales, and algebraic achievement gain during the course.

HYPOTHESES

To achieve the purpose of providing a clearly defined current study on problem posing instruction, information was sought concerning relationships of cognitive learning styles, algebraic achievement, and mathematics attitude for remedial algebra, community college students. The following null hypotheses were tested at a significance level of 0.05:

> H_1: There will be no significant difference between algebraic achievement scores of traditionally instructed students versus problem posing instructed students based on learning style classification and initial mathematics attitude.

H_2: There will be no significant difference between pre-instruction mathematics attitude scores and post-instruction mathematics attitude scores of traditionally instructed students versus problem posing instructed students.

Control and treatment groups were instructed for one semester. Data pertaining to mathematics achievement gain was obtained with pre-test and post-test using the College's final examination for MATH-0710. Mathematics attitude data was obtained by pre-test and post-test with Fennema-Sherman Mathematics Attitude Scales. Student learning style was determined by pre-test with Kolb's Learning Style Inventory (LSI-IIa).

ASSUMPTIONS

The following assumptions were made for this study:

1. Students have a particular learning style that can be measured.
2. Measurement instruments selected for evaluating mathematics achievement, attitude, and cognitive learning style are valid and reliable instruments for this study.
3. Kolb's Learning Style Inventory (LSI-IIa) measures the learning style of the study population.

4. Learning style as determined by Kolb's Learning Style Inventory (LSI-IIa) is a stable characteristic for community college students.

5. Students responded honestly to questions concerning their learning style preferences and mathematics attitudes.

6. The researcher, who taught both control and treatment classes, introduced no bias into the study.

LIMITATIONS

The study was limited in the following ways:

1. Student responses to measurement instruments of cognitive learning preference, mathematics attitudes, and mathematics achievement may be inaccurate.

2. Reliability and validity of cognitive learning preference test, mathematics achievement test, and attitude tests may be in error since they depend on student response.

3. The study consists of a convenient, volunteer sample of students enrolled in day classes at Walters State Community

College and the results may not be compared to other schools or students.

4. The students were not individually, randomly assigned to control or treatment classes; instead, whole classes were randomly selected to serve as either a control or treatment class.

DELIMITATIONS

Students were day students enrolled at Walters State Community College in MATH-0710 for the fall semester, 1997, on the main campus in Morristown, Tennessee. The research analysis was limited to students who completed the semester of work and participated in all research testing.

DEFINITIONS OF TERMS

The following definitions of terms were used in the study:

Learning Style: A student's consistent way of responding and using stimuli in the context of learning (Claxton & Ralston, 1978).

Kolb Learning Style Inventory (LSI): A model of cognitive learning style which describes learners as belonging to one of four classifications of learners (Kolb, 1984).

Kolb's Learning Cycle: A four stage model describing how experience is translated into concepts which becomes the guide in the choice of new experience. The cycle consists of concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) stages (Smith & Kolb, 1996).

Four Stages of Kolb's Learning Cycle:

Concrete Experience (CE): In this LSI learning stage, the learner relies more on feelings than on a systematic approach to problems and situations. Personal involvement with people in everyday situations is emphasized. The learner relies on his ability to be open-minded and adaptable to change. Learning is from feeling (Kolb, 1993).

Reflective Observation (RO): In this LSI learning stage, the learner relies on understanding ideas and situations from different points of view. Patience, objectivity, and careful judgment are shown, but not action. The learner relies on his thoughts and feelings in forming opinions. Learning is by watching and listening (Kolb, 1993).

Abstract Conceptualization (AC): In this LSI learning stage, the learner relies on using logic and ideas, instead of feelings, to understand problems and situations. Systematic planning and theories are used to solve problems. Learning is by thinking (Kolb, 1993).

Active Experimentation (AE): In this LSI learning stage, the learner relies on an active, practical approach to learning with concern about what really works. Getting things done and seeing the results of influence is sought. Learning is by doing (Kolb, 1993).

Kolb's Four Learning Style Types:

Accommodator: This learning style combines the learning stages of concrete experience and active experimentation. This learner enjoys carrying out plans and becoming involved in new, challenging experiences. His action may be on feelings instead of logical analysis (Kolb, 1993).

Diverger: This learning style combines the learning stages of concrete experience and reflective observation. This learner approaches situations by observing concrete situations from many different viewpoints, brainstorming and gathering information. He has imaginative ability and sensitivity to feelings (Kolb, 1993).

Converger: This learning style combines the learning stages of abstract conceptualization and active experimentation. This learner seeks practical uses for ideas and theories. He has the ability to solve problems and make decisions, however, these problems are limited more to technical tasks than social or interpersonal issues (Kolb, 1993).

Assimilator: This learning style combines the learning stages of abstract conceptualization and reflective observation. This learner is more interested in abstract ideas and concepts than in people. He takes a wide range of information and puts it in concise, logical form; it is the logic of a theory rather than its practical value that is of concern (Kolb, 1993).

Other Terms:

Achievement gain score: Post-treatment examination score minus pre-treatment examination score.

Attitude: The learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object (Aiken & Dreger, 1961).

Attitude gain score: The post-treatment attitude score of the Fennema-Sherman test minus pre-treatment score thereby giving either a positive score, a zero score, or a negative score.

Problem posing: The generation of new problems and the reformulation of given problems in mathematics instruction (Silver, 1994). This study dealt only with the generation of new problems.

ORGANIZATION OF THE STUDY

This study is organized into five chapters. Chapter I contains an introduction of the study, a statement of the problem, the purpose and need for the study, assumptions, limitations, delimitations, definition of terms, hypotheses, and organization the study. Chapter II is a literature review of mathematical problem posing instruction, student learning styles, and mathematics attitude as they relate to mathematics achievement. Chapter III contains a discussion of the methodology and study procedures. Chapter IV reports the statistical analyses of the data. Chapter V provides a summary of the results and outlines conclusions and recommendations for further study.

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

The purpose of this study was to investigate relationships concerning problem posing instruction, student learning styles, and mathematics attitudes for remedial mathematics students in a rural community college. Student learning style was studied using Kolb's experiential learning model, and mathematics attitudes were studied using the Fennema-Sherman Mathematics Anxiety Scale.

This literature review consists of three sections exploring the following topics: (a) problem posing instruction, (b) student learning style, and (c) mathematics attitude. The problem posing section presents a theoretical basis for problem posing instruction, discusses relationships of problem posing with student creativity and mathematical knowledge, and reviews achievement results in classrooms using problem posing instruction.

The learning style section presents a choice of learning style models available for characterizing student learning styles. Each model selected is discussed in regards to characteristics tested, target populations, and assessment instruments. Learning style traits of students who succeed in mathematics are discussed. Kolb's experiential learning theory is discussed in greater detail than the other theories since it was the model selected for this study. Discussion of Kolb's experiential theory examines learning style distributions pertaining to the target community college population, it discusses the relationship of student learning style and course achievement, and it comments upon possible findings concerning learning styles and problem posing instruction.

The mathematics attitude section introduces basic findings, discusses the influence of mathematics attitude on mathematics achievement scores, and reviews mathematics attitude changes resulting from problem posing instruction. Particular attention is paid in all three sections to community college remedial mathematics students.

Problem Posing Instruction

Problem posing instruction involves instruction with student generation or formulation of problems to solve (Silver, 1994). It involves the creation of original problems which may be associated with particular conditions. For this study, problem posing instruction does not pertain to the restatement of a given problem in the process of problem solving. Problem posing may be considered to be problem finding or formulation.

Problem posing instruction is recommended by the National Council of Teachers of Mathematics (NCTM) in *Curriculum and Evaluation Standards for School Mathematics* (1989) with the statement that students should "have some experience recognizing and formulating their own problems, an activity that is at the heart of doing mathematics" (p. 138). Instructor modeling and emphasizing of problem posing is recommended in the *NCTM Professional Standards for Teaching Mathematics* (1991) wherein it is stated that "students should be given opportunities to formulate problems from given situations and create new problems by modifying the conditions of a given problem" (p. 95). Kilpatrick (1987) recommended that problem posing be viewed not only as a goal of instruction, but as a means of instruction.

Education studies have largely ignored problem posing to concentrate on skills in problem solving (Dillon, 1982). Although problem posing instruction seems as if it would be accepted by students and promote both achievement and positive learning attitudes, investigations into its classroom use are lacking (Silver, 1994). Might some mathematics students have difficulty with problem posing instruction? What are the characteristics of mathematics students who respond positively and benefit from problem posing activities?

Problem posing is associable with Polya's (1957) four stage model of problem solving. Polya's model states that the problem solver must understand the problem, devise a plan, carry out the plan, and then look back at his action. The last stage of "looking back" involves checking for correctness and determining if the best route for solution were applied. The "looking back" stage additionally asks the problem solver to pose or formulate original problems that are in some way related to the problem just solved. One example of problem posing instruction is demonstrated by Brown and Walter (1983) in geometry lessons which ask, "What-if-not?" of conditions in a previously solved problem.

Problem posing instruction may be studied with respect to numerous variables. The following list indicates some variables currently explored in problem posing research: the formal training of students to pose mathematics problems (Hashimoto, 1987; Keil, 1964; Perez, 1985), the quality of problems produced by students (Hashimoto, 1987; Leung, 1993; Schloemer, 1994; Silver & Cia, 1996), the influence of solving stated problems upon following problem posing tasks (Leung, 1993; Silver and Mamona, 1990), and the influence of group work on problem posing instruction (Silver, 1990). Two additional variables examined in the literature are student creative ability and student mathematical knowledge or ability. Since these two variables may show relationships to factors of this study, they will be reviewed with some detail.

In John F. Wakefield's (1991) review of divergent-thinking tests, the French philosophy teacher, Paul Souriau is cited as being an initial investigator of problem posing with his 1881 study of inventions. Souriau observed that the truly original mind is capable of finding problems. Problem posing was classified in Wakefield's study as a skill belonging to the creative, divergent thinker. Based on the assumption that creative ability and problem posing ability are positively related, Getzel and Jackson (1962) developed a creative ability test requiring problem posing. Subjects were instructed to make-up as many problems as possible based on a given paragraph of data. Creativity scores depended on the number, appropriateness, complexity, and originality of problems generated.

In a later study of creativity involving mathematics students, Balka (1974) similarly stated that creativity is an intellective mode characterized by divergent thinking. Balka measured creativity in mathematics as a result of the number or fluency of mathematics problems posed, the different types or flexibility among problems, and the uniqueness or originality of posed problems. To be classified as creative, a mathematics student had to show both fluency and flexibility; merely a large number of problems did not illustrate mathematical creativity.

In research studying problem posing traits of adult, elementary school teachers, Leung (1993) studied relationships between creative thinking ability and the quality and quantity of mathematics problems posed. The creative thinking ability of subjects was measured by the Torrance Test of Creative Thinking, a verbal test of creativity. No statistical difference was found between high and low creative thinking groups for the quality of problems posed. High level creative thinking subjects tended to be more fluent in producing problems; however, the additional problems posed showed only added story dimensions not mathematical variations. Leung's research found no support for the long held belief in the need of high level creative ability or divergent thinking skills to be a good problem poser. Leung's study indicated that problem posing instruction need not be reserved in the mathematics class for exceptionally talented or creative students (Silver, 1994).

Haylock (1987) also observed that mathematical creativity might not be an independent variable, but a variable dependent upon other characteristics such as mathematical knowledge. Haylock proposed that fluency and flexibility of problems posed by mathematics students is reflective of the student's mathematical background and ability. Research relating mathematical knowledge and problem posing performance is reviewed in the following studies.

Leung (1993) showed both quantitative and qualitative differences in problem posing performance with respect to the poser's mathematical knowledge. Subjects of higher mathematics knowledge produced more problems in areas which could be classified as plausible, solvable, and multi-step problems. Higher knowledge students showed systematic manipulation of conditions and goals producing problems which were related to each other in solution structures. The ability to "see ahead" in the planning stage of problem posing was demonstrated by the higher knowledge students who avoided insufficiency in data before presenting the problem to be solved. Students who rated low in knowledge and high in creative ability focused on the story components of the posed problems. Students who rated low in both knowledge and creative ability posed problems low in story components and interrelated solution structures.

Research on children by Krutetskii (1976) and Ellerton (1986) also showed mathematics students of higher mathematical ability to be better problem posers. Ellerton instructed 11 to 13 year old students to make up mathematics problems that would be difficult for a friend to solve. Ellerton described these problems as being reflective of problems that would be difficult for the problem posing students to solve themselves. The more knowledgeable students posed problems requiring greater computation skills, more operations, and more complex number systems such as decimals and exponents. The more able students also planned problems to afford cancellation of fractions and readily performed calculations. Students of higher ability could solve their own problems, and did so correctly, more often than did less able students.

In a problem posing study of elementary third grade students, English (1998) rated students according to their mathematical ability in number sense and problem solving skills. She concluded that to achieve diversity in problem posing ability, students required development in skills of number sense and in skills of problem solving. Silver and Cai (1996) found that middle school students, who were good problem solvers, could generate more mathematical problems than the poor problem solvers; problems posed by good problem solvers reflected more mathematical complexity.

Research concerning classroom usage of problem posing instruction and resultant mathematics achievement is somewhat limited. Most research involving achievement is focused on elementary and middle school students rather than on older students of high school or community college level. Due to the shortage of data concerning older students, research studies related to students younger than the target population of this study are included in the following review of problem posing in the mathematics classroom.

Jan van den Brink (1987) conducted a year long problem posing study with the assistance of two first grade teachers. The first grade students in both classes were given the problem posing project of writing an arithmetic book for the next year's first grade students. High achievement and positive attitude responses were shown in both classes. The students took pride in writing a book; they set goals of clarity, correctness, and usefulness for their product. The students demonstrated critical thought processes while discussing arithmetic skill levels appropriate for particular sections of their book. A comparison of books composed in classes having different teachers, reflected the teaching styles of the instructors. Students instructed with basic computation lessons posed only computation problems, but students taught with application problems posed word problems dealing with daily life.

In a study of problem solving achievement of fifth grade students, Van Horn (1994) instructed control and treatment students with problem solving heuristics. Along with the heuristics instruction, the treatment group wrote original story problems which suited the heuristic being studied. The treatment group compiled a problem solving book containing their original problems. Based on pre-test and post-test results, the treatment group outperformed the control group in problem solving achievement.

Hashimoto (1987) found an increase in problem solving achievement for fifth grade students who posed problems similar to problems just solved during the class lesson. He theorized that to pose a similar problem the students must reflect on the essential structure of the original problem and transfer this information into a new situation. The students reviewed their classmates' original problems and selected the more challenging ones to solve.

Keil (1964) found an increase in problem solving achievement for fifth and sixth graders who wrote original, verbal arithmetic problems. In the sixteen week study, treatment students were provided with a story or situation to use as a guideline for writing problems; control students were taught with traditional, textbook methods. An example of a guideline story for the treatment group is as follows: "The children of Mrs. Holtz's fourth grade class have printed two issues of their class paper. What were some of the problems the children had to solve as they wrote, printed, and sold their paper?", p.82. High and middle rated achievers of the treatment group showed benefit from the problem posing exercises by scoring significantly higher than comparable students of the control group. No difference in problem solving was seen for low achieving students in treatment or control groups.

In a similar study of posing original problems based on a mathematics story, Williams (1994) used a video presentation for sixth grade classes. Using a computer environment, the students studied the qualitative relationships among the variables of the video problem; students then posed new problems based on the video story. The computer environment enabled students to make predictions about and solve the new problem. The treatment students achieved higher in problem solving performance than did control students. Control students were instructed with computer drill and practice exercises during the study.

Winograd (1990) conducted ethnographic case studies of the cognitive behavior of fifth grade students involved in inventing original word problems. Students were supplied with no story or situation to guide them in posing problems; the students were also free to pick any mathematical topic for their original problems. The problems posed were reflective of student experiences, interests, and imagination. For any ability level student, the posed problems were discovered to reflect problems which the poser had difficulty solving himself. Although no control group was available for comparison, Winograd reported problem posing exerted a positive effect on problem solving performance.

Lodholz's (1980) interdisciplinary problem posing study required middle school students to pose problems satisfying specified mathematical and language components. The mathematical components referred to mathematical situations such as hidden numbers, extraneous numbers, and multiple operations; the language components referred to language components such as pronouns, conjunctions, and relative clauses. After solving the instructor's problems illustrating specific components, students composed problems consisting of the same components. Problem solving performance of control and treatment groups showed an analysis of covariance value of $p = 0.125$; Lodholz concluded that problem writing serves to improve student problem solving performance.

In an exploratory study with high school students, Borba (1994) investigated how students coped with the task of posing their own mathematics problems based on a theme they selected. One study group selected to study inflation and the price of housing. The students decided what data to collect, how to collect it, and what calculations were needed to answer particular questions concerning their theme. After a nine week study, Borba concluded that problem posing conducted in this manner is feasible for the classroom, and it exposes students to areas of mathematics absent from regular mathematics classes. This type of instructional program was termed by Borba as a means of democratizing the classroom by empowerment of students.

In case studies with community college algebra students, Gage (1982) compared problem solving processes students used in solving ready-made problems as opposed to processes they used in solving original problems. The most able solvers of ready-made problems were not necessarily the most able solvers of the posed problems, nor were the least able solvers of ready-made problems the least able solvers of posed problems. Gage concluded that the process of forming and solving mathematical problems gave students access to an increased range of mathematical processes and strategies.

In an exploratory study of community college, remedial algebra students, Perez (1985) examined the effects of writing mathematics problems on problem solving performance. Students were taught to pose problems according to a given pattern and then to solve their problems using the same pattern in reverse. Perez reasoned that if a student could write a problem, there was a high probability he could solve another problem similar to it. Most students felt the process improved their problem solving ability, however, no control group or comparison means was used.

In a study applying "what-if-not" problem posing instruction with college algebra students, Schloemer (1994) found no significant difference in problem solving achievement between control and treatment groups. Treatment student were taught using problem posing activities as a part of daily lessons; control class used the extra class time with textbook exercises. Schloemer commented that although problem posing instruction appears to be a feasible means of instruction, more practical information about its use is needed.

Review of current research on mathematical problem posing instruction shows few studies available concerning community college students. Although elementary and middle school research points toward achievement gains when using problem posing lessons, research with older mathematics students shows mixed results. Research investigating cognitive processes of students posing problems is inconclusive. Do students need high creative ability or divergent thinking skills to be good problem posers? Do students with low mathematical knowledge or ability benefit from problem posing instruction?

LEARNING STYLE

Learning style refers to a person's consistent way of responding to and using stimuli in the process of learning (Claxton & Ralston, 1978). It is a composition of one's cognitive, affective, and physiological domains; and it provides relatively stable indicators of perception, interaction, and response to the learning environment (Keefe, 1979). Placing a student in a learning style environment unmatched to his style, requires him to spend some learning energy making necessary adjustments (Jenkins, 1988). A learning style indicates not only how a student exceeds in learning, but how he enjoys going about it (Keefe, 1988). Attitudinal changes for students are dependent on matches of learning style and instruction style (Davis, Murrell, & Davis, 1988).

Due to the large number of identifiable cognitive traits, great dissimilarity among learning style instruments exists. For example, cognitive tests are available in such diverse areas as field dependence-independence, impulsivity-reflectiveness, and preceptiveness/receptiveness-systematicness/intuitiveness. A sampling of learning style theories and inventories is provided in the following paragraphs. For the learning theories reviewed, traits belonging to students who performed well in mathematics are cited.

The learning style model developed by Dunn and Dunn considers both biological and developmental characteristics of students in search of how they concentrate and learn (Dunn & Dunn, 1978). Evaluation of students according to their environmental needs, emotionality, sociological needs, and physical preferences provides a comprehensive personal profile for students in all areas of life. Students are studied in respect to how they concentrate on, absorb, and retain new information. The environmental assessment involves student preferences of sound, light, temperature and design of the learning environment. The emotional factor studies the student's levels of motivation, persistence, and responsibility. Sociological factors determine the relation of the learner to peers, self, teams, and adults. The physical circumstances test includes factors of time management, mobility, and perceptual preferences. Perceptual preferences rate learners as being auditory, visual, tactual, and kinesthetic. The Dunn LSI test instrument is a 104 item, true or false test; the learner is evaluated according to 36 sub-scales. The Dunn LSI was originally designed for elementary and middle school students, but versions of the test are now used with high school students and adults. Although the Dunn LSI is a widely used instrument and has the strength of encompassing physiological and affective behaviors, it is considered by some researchers to lack a clearly defined cognitive domain (Karrer, 1988).

Canfield's Learning Style Inventory (Canfield, 1988) obtains student descriptions of learning styles based on educational experiences that students report they prefer. Students are polled for preferences in the following categories: conditions of instruction (peer, organization, goal setting, competition, instructor, detail, independence and authority), areas of interest (numeric, qualitative, inanimate, and people), modes of leaning (listening, reading, iconic, and direct experience), and expectations for course grade. Learners are described as belonging to one of eight learning styles; these styles are depicted by terms such as social/applied, applied, and social/conceptual. Canfield's inventory has validity and rather high reliability (Matthews, 1991).

The field dependent-independent cognitive model of Witkin describes subjects as global versus analytical perceivers of information (Claxton & Ralston, 1978). For example, some people can easily see or locate a simple figure embedded within a more complex one, while others are unable to make a distinction of the figures at all. Persons influenced by the surrounding field are termed field dependent, and those not influenced by the background are termed field-independent. Witkin has done extensive studies since the 1940's relating cognitive and behavioral characteristics to field-dependency. Three tests are used to evaluate field-dependency: the Body Adjustment Test (BAT), the Rod and Frame Test (RFT), and the Embedded Figures Test (EFT). All three tests yield satisfactory reliability coefficients in terms of internal consistency and test-retest analyses. Field-dependency evaluations are used in student career guidance and counseling situations. In the area of mathematics, field-independent students function better than field-dependent students.

Originally derived by Carl Jung, the Myers-Briggs Type Indicator (MBTI) classifies persons by scales of introversion versus extroversion, thinking versus feeling, and judgment and perception (Rule & Grippin, 1988). The scales of introversion (I) and extroversion (E) determine if a person gains energy by looking outward or inward in relation to self; the scales of judgment (J) and perception (P) determine how a person will consciously sense the environment as physical components or matter beyond the physical being. The scales of thinking (T) and feeling (F) determines the person's strategy for judging environmental stimuli or attitude toward the world. A person is classified in reference to 16 learning types, and as having a "psychological type" and a "shadow figure." Learning or personality styles are reported by four letters, such as ISTP. Persons classified as sensing (S) and thinking (T) tend to focus on reality and are objective in analysis, they are practical and analytical. Students with traits of IST and EST tend to be good mathematics students; they are either introverts or extroverts and they are sensing and thinking people (Purkiss, 1994).

Entwistle's learning styles classify learning as occurring through four basic processes. In order for deep comprehensive learning to occur, all four of the processes must work together. These learning processes are listed as follows: a) building an overall description of the content area, b) reorganizing incoming information to relate to previous knowledge and establishing personal meaning, c) paying detailed attention to evidence and steps in an argument, and d) relating evidence to conclusions and maintaining an objective stance. This model offers a holistic view of learning style evaluation, and it is helpful to instructors in evaluating inappropriate learning behavior of students (Karrer, 1988).

Hunt's Conceptual Levels (CL) model describes the degree of structure a student needs to learn effectively. Students needing high structure are found to be impulsive and to have a low frustration tolerance level. Students needing medium level structure like categories and believe in authorities. The student requiring less structure is independent, often self-employed, and looking for alternatives. Hunt's test instrument may be difficult for the evaluator to interpret since it is conducted with free-style writing of the student. Hunt's model focuses only on the affective domain of students. Students who are good in mathematics are those requiring structure (Karrer, 1988).

The Grasha-Riechman Model looks at types of responses given by students, and it characterizes student learning styles through traits of these responses. Response styles are classified as avoidant or participant, competitive or collaborative, and dependent or independent. A similar tactic by Stern to describe how students will behave in the classroom, classifies student behavior as being authoritarians, antiauthoritarians, or rationals (Claxton & Ralston, 1978).

To offer informative and global instruments for learning style assessment, integrated testing models encompassing learning theories, individual development styles, and personality types have been designed. One widely used integrated model, for college age learners, is Kolb's experiential learning model (Claxton & Ralston, 1978). Kolb (1984) defines learning as the process whereby knowledge is created through the transformation of experience. Kolb's experiential learning theory is based on the learning models of Lewin, Dewey, and Piaget. The Lewian model is a four stage cycle wherein the learner undergoes a concrete experience, observes and reflects on it, generates abstract concepts, and then acts on the newly formed concepts. Repetition of this cycle generates knowledge. From Dewey, comes the idea of dialectic opposites existing in our perception of new information and in our subsequent processing of it. Dewey says we perceive new information either through concrete experience or abstract thought; and we choose to process information either through reflective observation or active experimentation. Piaget's theory claims one's view of the world, from infancy through adulthood, develops through stages of concreteness to abstractness, and through processes of activeness to reflectiveness. Cognitive growth occurs between an individual and his environment by accommodation of concepts and assimilation of events.

Kolb's Learning Style Inventory (Kolb, 1993) is composed of a 12-item questionnaire which asks the test taker to rank order four sentence endings describing how he prefers to learn. The sentence endings correspond to the learning preferences of concrete experience, abstract conceptualization, active experimentation, or reflective observation. Learning styles are determined as being one of four types depending on the intersection of the learner's concrete-abstract dimension score with his active-reflective dimension score. In a clockwise fashion, the four learning style quadrants are labeled diverger, assimilator, converger, and accommodator.

Learners are theorized by Kolb to perceive and process new information through different learning modes. Accommodator and diverger learners prefer to perceive information through concrete experience, but assimilator and converger learners prefer to perceive information through abstract conceptualization. Assimilator and diverger learners prefer to process information through reflective observation, but accommodator and converger learners prefer to process information through active experimentation. The effective learner is well balanced in all four styles, and able to shift skills around the learning cycle. He is able to become involved, to listen, to create ideas, and to make decisions (Kolb, 1993). A description of strengths, weaknesses, and improvement recommendations for each learning style is given in Figure 1.

Kolb (1993) provides a demographic analysis of a normative sample of post-secondary, male and female subjects describing the relation of sex, age, and educational level to learning style traits. In general, subjects with a fifty percentile or greater tendency for using abstract thought, instead of concrete experience, are male: or age 25 to 32 years, or older than 45. Their education level is at least some college work. Subjects showing a fifty percentile or greater tendency for active experimentation, instead of reflective observation, are of either sex, older than 25 years, or have at least some college work. The traits of age, sex, and educational background are major descriptors associated with community college students and classes; Kolb's analyses provide implications for performance characteristics.

The chart below identifies the strengths and weaknesses of each learning style with notes for improvement.

Concrete Experience

ACCOMMODATOR

Strengths: Getting things done
Leadership
Risk-taking

Too much: Trivial improvements
Meaningless activity

Not enough: Work not completed on time
Impractical plans
Not directed to goals

To develop your Accommodative learning skills, practice:

- Committing yourself to objectives
- Seeking new opportunities
- Influencing and leading others
- Being personally involved
- Dealing with people

DIVERGER

Strengths: Imaginative ability
Understanding people
Recognizing problems
Brainstorming

Too much: Paralyzed by alternatives
Can't make decisions

Not enough: No ideas
Can't recognize problems and opportunities

To develop your Divergent learning skills, practice:

- Being sensitive to people's feelings
- Being sensitive to values
- Listening with an open mind
- Gathering information
- Imagining the implications of uncertain situations

Active Experimentation

Reflective Observation

CONVERGER

Strengths: Problem-solving
Decision-making
Deductive reasoning
Defining problems

Too much: Solving the wrong problem
Hasty decision-making

Not enough: Lack of focus
No shifting of ideas
Scattered thoughts

To develop your Convergent learning skills, practice:

- Creating new ways of thinking and doing
- Experimenting with new ideas
- Choosing the best solution
- Setting goals
- Making decisions

ASSIMILATOR

Strengths: Planning
Creating models
Defining problems
Developing theories

Too much: Castles in the air
No practical application

Not enough: Unable to learn from mistakes
No sound basis for work
No systematic approach

To develop your Assimilative learning skills, practice:

- Organizing information
- Building conceptual models
- Testing theories and ideas
- Designing experiments
- Analyzing quantitative data

Abstract Conceptualization

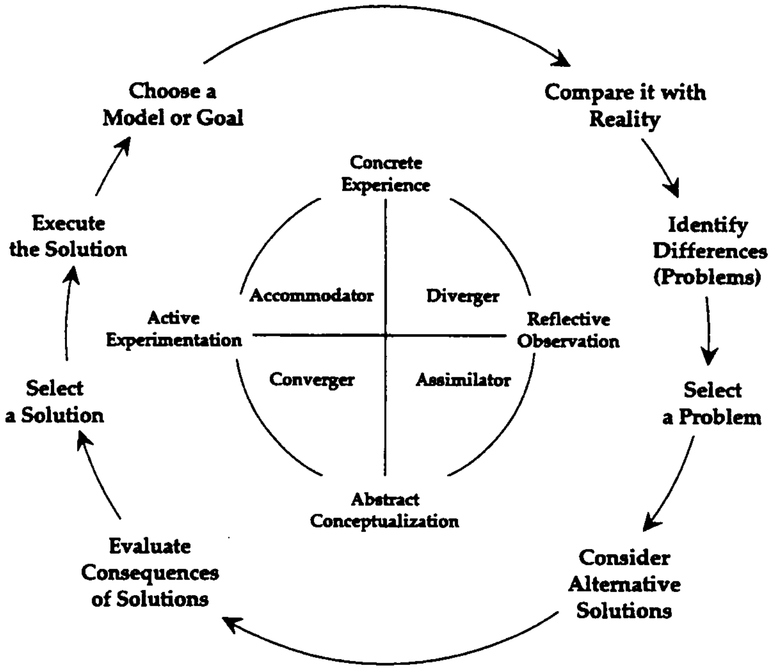
McBer & Company 11

Figure 1. Kolb's Learning Style Model.

Kolb (1993) suggests that employing the learning cycle can strengthen problem-solving performance. Figure 2 provides a comparison of the learning cycle with the problem solving process. Problem solving skills involve identifying the problem, selecting the problem to solve, seeing different solutions, evaluating possible results, and implementing the solution. Students who rely heavily on concrete experience can identify problems that need to be worked or solved. However, students who rely on abstract conceptualization prefer to evaluate possible solutions. Active experimentation students have strong points in implementing solutions, but reflective observation students show strength in selecting a problem. Accommodator and diverger learners show characteristics of skills needed in problem posing. The diverger learner, in particular, shows problem posing strengths from two different learning modes.

Studies comparing learning style distributions of remedial and college level mathematics students showed no significant difference between the two groups. In the dimension of new information perception, however, remedial students preferred concrete experience, but college level students preferred abstract conceptualization (Buchanan, 1992; Kristofco, 1991). Kristofco showed active experimentation, or group work to be preferred by remedial students, but not by college students. Hinterthuer's (1984) study supported both these findings and indicated remedial students preferred concrete experience over abstract conceptualization, and active experimentation over reflective observation. Research by Altieri (1987) presented

Comparison of the Learning Cycle with Problem-Solving Skills



The next section contains strategies to help you develop your learning skills.

Figure 2. Comparison of Learning Style with Problem Solving Process.

opposite results, however, with remedial students yielding low scores in concrete experience and high scores in reflective observation.

Non-remedial, community college students showed practically a 1:2:1:1 ratio of diverger: assimilator: converger: accommodator learners (Shelton ,1995; Harland-White,1993; Joerger, 1992). The large ratio, of assimilator learners compared to other learning styles, indicated a preference for the combination of abstract conceptualization and reflective observation modes for college level students. Purkiss (1994) found a different distribution of learning styles for freshmen, community college students; he cited 31% diverger, 36% assimilator, 13% converger, and 19% accommodator. The large percentages of diverger and assimilator learners indicated agreement with other research studies wherein reflective observation style was preferred for non-remedial, community college students. Caskey (1981) and Lindsey (1987) showed community college students were relatively homogeneous groups who preferred to receive information concretely and process it reflectively. A conclusive description of the learning characteristics to expect of community college students is not provided in the literature.

Studies concerning relations between student learning styles and course achievement showed mixed results. Studies by Shelton (1994), Harland-White (1993), Davis (1988), Taylor (1986), and Hinterthuer (1984) found no correlation between learning style type and course achievement. However, Purkiss (1994), Carthey (1993), Buchanan (1992), and Caskey (1981) showed abstract conceptual learners outperformed concrete experience learners; Carthey was even more specific and described the highest achieving learner as the converger learner. Carthey, Buchanan, and Caskey showed the lowest performer was the diverger learner. Caskey made a curious discovery when he observed that student socioeconomic backgrounds correlated with their learning style characteristics. He found lower socioeconomic groups preferred a more concrete learning style.

While studying traits of college age students applying problem posing instruction, Dillon (1988) theorized that good problem posers have "a preference for wondering rather than explaining, for discovering over telling, for being inquisitive rather than informative, for questioning over answering" (p. 113). Whether problem posing instruction suits particular learning style students, but not others, is an area that needs study and its results applied in the classroom.

Mathematics Attitude

Mathematics educators of the 1960s and early 1970s applied the term "attitude toward mathematics" to refer to areas specifically in the affective domain (Hart, 1989). Attitude toward mathematics was defined as "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics can be useful or useless" (Neale, 1969). Multidimensional views of mathematics attitude progressed toward the latter 1970s. Attitude toward mathematics, in current research, reflects more than just the affective domain; it encompasses any one of a number of perceptions about mathematics, oneself, mother, father, or teacher (Hart, 1989). Studies of mathematics attitude are numerous, and reflect varied areas such as intelligence, race, teaching methodologies, and socioeconomic background.

Disagreement exists in the literature in several areas of study about mathematics attitude. One such area of major concern is the relationship between attitude toward mathematics and achievement in mathematics. To integrate and summarize research concerning this relationship, Ma and Kishor (1997) conducted a meta-analysis on 113 attitude studies, involving 82,941 students, from 1966 through 1993. This analysis showed a positive and reliable correlation between attitude toward mathematics and achievement; however, the relationship was not strong and deemed of no practical, educational value. Analysis of other factors showed: secondary level students exhibited more dependency on attitude than elementary level students; Asian students were influenced more by attitude than White or Black students; and gender made no difference. The correlation of attitude and achievement variables displayed a noticeable increase in post-1975 research studies. Ma and Kishor speculated this increase is due to improvements in test instruments and the treatment of negative attitudes by mathematics educators. The authors confirmed the complexity of studying mathematics attitude and recommended further studies to broaden understanding.

Elementary and secondary students are the subjects of most mathematics attitude studies; and, research related to community college students is limited. Most attitude tests concerning community college mathematics students are encountered as supplemental topics in instructional research. The following studies, however, analyzed mathematics attitude as a predictor of traditional course success for community college students.

Cox (1993) sought to develop a tool to identify at-risk, community college, basic mathematics students through analysis of their initial attitude toward the course. He found the relationship of the attitude score and course grade revealed no instrument for academic prediction. Two similar studies, however, did show a relationship. In an investigation of the relation of mathematics attitude to success, Rives (1992) studied 1550 community college mathematics students. Mathematics attitude showed a direct and positive relation to achievement for these students. In a study on 513 developmental mathematics students, Elderveld (1983) showed mathematics attitude was a determinant of success or failure.

Using Kolb's Learning Style Inventory and Fennema-Sherman Mathematics Attitudes Scales, Buchanan (1992) revealed significant relationships between learning styles and mathematics attitude changes for both remedial and college level students. Mathematics attitude changes were negatively correlated with the reflective observation scores for both groups of students. Remedial students, with high concrete experience scores, showed positive attitude changes; however, college level students with high concrete scores showed no positive attitude changes. Altieri (1987) found remedial or college level students who reported anxiety as a major learning problem, showed high concrete experience scores.

Moses (1990), Winograd (1990), Silver (1990), and Bush (1986) suggest that problem posing instruction might reduce student anxiety and improve student attitude. Brown and Walter (1983), in the *Art of Problem Posing*, likewise suggest that problem posing instruction might reduce student anxiety because it is less threatening to ask a question than to answer one. However, they observe the possibility of intimidation still logically exists since questions could be rated as either good questions or bad questions.

Attitude research involving problem posing students is sparse. In an exploratory study of remedial algebra, community college students, Perez (1985) examined attitude and achievement scores of students composing and solving their own word problems. Student problem solving attitude was studied in regards to student anxiety, self-concept, enjoyment, and motivation. At the beginning of the study most students were against or strongly against word problems, but after the study most students had changed their view and were in favor or strongly in favor of word problems. No student was strongly against word problems at the end of the study. Attitude evaluation in this study was based on an assessment instrument composed by the researcher.

Schloemer (1994) found advanced algebra, high school students instructed with problem posing experienced an overall decrease in disposition. Students rated as high-achievers, based on prior class experience, showed a decrease in disposition during the study. Lower-achieving students displayed the opposite with a gain in disposition. Schloemer theorized the high-achiever may have felt problem posing as a threat to traditional, successful settings, whereas, the low-achiever may have felt problem posing offered a means for improvement.

For lower grade students, Lodholz (1980) used story problem writing to study problem solving achievement and attitude change of intermediate fourth and fifth grade mathematics students. Student attitude was measured by an instrument developed by the researcher wherein he asked students to respond with a "yes" or "no" to statements such as: "I enjoy math." and "My attitude toward math has changed this year." Although no difference in achievement was found for the students, a significant difference in attitude change was observed.

SUMMARY

A literature review of topics pertaining to problem posing instruction, student learning style, and mathematics attitude was done. Information relating to the target population of remedial, community college students and to the hypotheses of the study was sought. Problem posing instruction showed positive influence on mathematics achievement of elementary and middle school students; however, studies involving older students showed mixed results. Attitude response to problem posing instruction showed generally positive results for younger students, but both positive and negative changes for older students. Research also showed that students need not possess the trait of high creative ability to pose good problems; this finding is cited as opening problem posing instruction to students of varying creativity levels.

No studies were found relating problem posing instruction and student learning style inventories. Research on the use of problem posing instruction with community college students is needed to determine relationships of student learning style, mathematics attitude, and mathematics achievement.

CHAPTER III

METHODOLOGY

INTRODUCTION

To achieve the purpose of providing a clearly defined, current study on problem posing instruction, information was sought concerning relationships of cognitive learning styles, algebraic achievement gain, and mathematics attitude. This study is important because it examines how problem posing instruction could influence mathematics achievement and attitudes of remedial algebra students. Using a quasi-experimental research design, the following null hypotheses were tested for significance at the 0.05 level:

> H_1: There will be no significant difference between algebraic achievement scores of traditionally instructed students versus problem posing instructed students based on learning style classification and initial mathematics attitude.

> H_2: There will be no significant difference between pre-instruction mathematics attitude scores and post-instruction mathematics attitude

scores of traditionally instructed students versus problem posing instructed students.

This chapter describes the experimental design of the study in areas such as study participants, course materials, instructional strategies, test instruments, hypotheses statements, and data analyses.

PARTICIPANTS IN THE STUDY

The study was conducted on six, intact classes, of remedial algebra students enrolled in MATH-0710 at Walters State Community College (WSCC), Morristown, Tennessee, during fall semester, 1997. The first day of class, students were informed of the study and given a choice of participation. Any student who wished not to participate could transfer to another class section or remain in the class without being a part of the study. All students chose to participate and subsequently signed a consent form. See Appendix B for a copy of the Human Consent Form. Of the 132 students initially volunteering to participate, 91 completed all instruments that were administered at the beginning and end of the study. The control group consisted of 68 initial participants of which 45 completed the study, and the treatment group consisted of 64 initial participants of which 46 completed the study.

Course

MATH-0710 is a 3 credit hour, basic mathematics course which offers an introduction to algebra with review of general arithmetic. Two courses, MATH-0820, elementary algebra, and MATH-0830, intermediate algebra, are the following courses in the WSCC developmental mathematics program. The course syllabus for MATH-0710 is a College syllabus which is used by all WSCC instructors. This syllabus is provided in Appendix C.

Students are placed in MATH-0710 by ACT or Academic Assessment and Placement Program (AAPP) test scores. The AAPP is a college placement test designed by the Tennessee Board of Regents for all state schools in its system. The AAPP is composed of three test batteries: Writing, Reading, and Mathematics. Students under 21 years of age must submit ACT scores for WSCC admission; applicants scoring less than 19 on the ACT mathematics sub-score must take the AAPP mathematics test for placement. Students 21 years of age or older must take all AAPP tests. Students who score at or below the 24th percentile on the mathematics test, which was appropriate to their high school background, are placed in MATH-0710 (WSCC, 1997).

Instructional Materials

The MATH-0710 textbook was *Prealgebra* by Katherine Yoshiwara, (1997). This textbook was designed to follow the NCTM and AMATYC reformed standards and to foster increased conceptual understanding in place of rote applications. Students were introduced to algebra as a language needed to solve problems. The text consisted of four units: (1) Variables and Equations; (2) Signed Numbers and Order of Operations; (3) Exponents and Fractions and (4) Proportion, Percent and Graphing. A review of basic arithmetic skills was offered for student reference in the appendix, but arithmetic skills were not presented as separate lessons. Textbook topics covered in MATH-0710 are provided in Appendix C.

Students were required to have a TI-83 graphing calculator for the course. During class time, the instructor used a TI-83 overhead calculator and provided departmental calculators for student use when needed. Calculators were permitted for use on homework and test papers.

Students in all research classes were given the same homework assignments, quizzes, and tests. Quizzes and tests were written by the instructor, however, the final examination was a College final examination. Students were not graded on problem posing responses or activities.

DESIGN

The study compared control and problem posing treatment groups of WSCC remedial algebra classes in areas of student learning styles, mathematics attitude, and mathematics achievement. Before Fall registration, six classes of MATH-0710 were selected by the Chairman of the mathematics department for the study. All six classes were selected from the day school, on the main campus, in such a manner that permitted one person to instruct all six classes. By random selection, three of these classes were assigned as treatment classes and three as control. Students were not informed by the researcher as to which research group their class belonged. Two control classes and one treatment class met for 55 minutes on Monday, Wednesday, and Friday each week; two treatment classes and one control class met for 85 minutes on Tuesday and Thursday each week. The semester was 15 weeks long.

The control classes were instructed in the traditional lecture manner; the treatment classes were taught the same as the control classes with incorporation of problem posing activities. The treatment classes received problem posing instruction during approximately one-third of every class meeting time. At the beginning of the semester, all pre-testing instruments were administered during class time. Problem posing treatment subsequently began and continued until the end of the semester. Post-treatment test instruments were administered the last two meetings of the semester. Both pre-treatment instruments and post-treatment instruments were scored after the semester was completed. Pre-treatment instruments were scored at this time to avoid researcher bias, and to simulate a traditional classroom setting wherein the instructor has no particular knowledge of student learning styles, mathematics attitude, or achievement level.

INSTRUCTOR

The researcher was the instructor in all six classes. The instructor had experience in teaching MATH-0710 and other remedial and developmental mathematics classes at WSCC. She had used problem posing activities with prior mathematics classes. The instructor did not test herself with the Kolb Learning-Style Inventory nor the Fennema-Sherman Mathematics Attitude test before the study, and she did not know her learning style preferences nor mathematics attitude ratings. Post-treatment Kolb Learning-Style Inventory showed the researcher to be of converger learning style.

INSTRUCTIONAL STRATEGIES

Two instructional strategies were used in the study: (1) traditional lecture and (2) traditional lecture with incorporation of problem posing instruction. Descriptions of these two strategies are provided in the following paragraphs.

Control Group-Traditional Lecture

The traditional lecture class consisted of the instructor lecturing, working examples, and answering student questions. The instructor worked problems and discussed examples given in the textbook. Any non-textbook problems were presented without discussion of their origin or composition. The teacher asked questions for open class response and encouraged student questions at any time.

Students worked in groups in time equitable to group work of the problem posing, treatment class. The instructor aided students in calculator use when needed.

Treatment Group-Traditional Lecture Plus Problem Posing

The traditional lecture format as described above was followed for approximately two-thirds of each class time with problem posing instruction applied one-third of each class time. Problem posing techniques were used every class meeting, except for days of chapter tests. Problem posing was used with the students during the lecture portion of class to develop their mathematical concepts and to promote higher order thinking skills. At the beginning of the study, students were not confronted with the term "problem posing", instead they were addressed with less formal terminology such as "make up problems," "write problems" or "change a question." This caution was suggested by a fellow teacher (Romines, 1997) to avoid possible negative associations with the term "problem solving." The process of posing problems was discussed and modeled by the instructor at the beginning of the study. Students independently posed problems after experiencing this group class practice. During lecture, students frequently wrote problems with the instructor and solved them together in class. The "What-if?" and "What-if- not?" strategy of Brown and Walter (1983) was used, as well as, those discussed by other authors (Fisher, 1993), (Gonzales, 1996), (Kimball, 1991), (Koenker, 1958), (Lopez-Real, 1995), and (Silverman et al., 1992). Students worked in pairs or small groups on instructor prepared problem posing worksheets. The instructor collected student posed problems and periodically compiled the problems for distribution to class members for solving. Appendix C contains a sample of teacher worksheets and student posed problems. The same degree of teacher positive reinforcement was sought for control and treatment classes.

INSTRUMENTS OF THE STUDY

Instruments used to collect data were the Fennema-Sherman Mathematics Attitudes Scales, Kolb Learning-Style Inventory (LSI-IIa), and the final examination for MATH-0710. At the beginning of the semester, the mathematics attitude, learning style inventory, and achievement test were given to all classes. At the end of the semester, mathematics attitude and achievement tests were re-administered to all classes. The learning style inventory was not repeated at the end of the course since learning style was assumed to be a stable trait and not likely to change within the time span of one semester. Mathematics achievement tests were the last tests given in both series of testing.

Fennema-Sherman Mathematics Attitudes Scales

The Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) was used to evaluate student mathematics attitude. This publicly available attitude test consists of nine domain specific tests which reflect learning mathematics attitudes; these tests may be used as separate tests or in any combination. The domain scales are identified and described as follows:

Attitude Toward Success in Mathematics (AS)

The attitude Toward Success in Mathematics Scale (AS) is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. They evidence this fear by anticipating negative consequences of success as well as by lack of acceptance or responsibility for the success, e. g., "It was just luck." (Fennema & Sherman, 1976, p. 2)

Mathematics as a Male Domain (MD)

Mathematics as a Male Domain Scale (MD) is intended to measure the degree to which students see mathematics as a male, neutral, or female domain in the following ways: a) the relative ability of the sexes to perform in mathematics: b) the masculinity/femininity of those who achieve well in mathematics; and c) the appropriateness of this line of study for the two sexes. (Fennema & Sherman, 1976, p. 3)

Mother and Father Scales (M), (F)

The Mother (M), Father (F) Scale is designed to measure students' perception of their mother's/father's interest, encouragement, and confidence in the student's ability. It also includes the student's perception of their mother's/father's example as an individual interested, confident, and aware of the importance of mathematics. (Fennema & Sherman, 1976, p. 3)

Teacher Scale (T)

The Teacher Scale (T) is designed to measure students' perceptions of their teacher's attitudes toward them as learners of mathematics. It includes the teacher's interest, encouragement and confidence in the student's ability. (Fennema & Sherman, 1976, p. 4)

Confidence in Learning Mathematics (C)

The Confidence in Learning Mathematics Scale (C) is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. The dimension ranges from distinct lack of confidence to definite confidence. The scale is not intended to measure anxiety and/or mental confusion, interest, enjoyment or zest in problem solving. (Fennema & Sherman, 1976, p. 4)

Mathematics Anxiety Scale (A)

The mathematics Anxiety Scale (A) is intended to measure feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics. The dimension ranges from feeling at ease to those of distinct anxiety. The scale is not intended to measure confidence in or enjoyment of mathematics. (Fennema & Sherman, 1976, p. 4)

Effectance Motivation Scale (E)

The Effectance Motivation Scale in Mathematics (E) is intended to measure effectance as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge. The scale is not intended to measure interest or enjoyment of mathematics. (Fennema & Sherman, 1976, p. 5)

Mathematics Usefulness Scale (U)

The Mathematics Usefulness Scale is designed to measure student' beliefs about the usefulness of mathematics currently and in relationship to their future education, vocation, or other activities. (Fennema & Sherman, 1976, p. 5)

This study used five of the domain scale tests: Attitude toward Success (AS), Confidence (C), Mathematics Anxiety (A), Effectance (E), and Usefulness (U). These five tests, consisting of twelve questions per test, offered a 60 item test. This test was randomly generated by computer program for a cumulative test. This test was the pre-study and post-study attitude test instrument. Appendix D contains the test used.

The Fennema-Sherman domain scales not used were the Male Domain (MD), Mother (M), Father (F), and Teacher (T). The Male Domain (MD) was not used since gender was not a factor being evaluated in the study; likewise, Mother(M) and Father (F) scales were eliminated since these factors were probably insignificant for college students. The teacher (T) domain was not evaluated since the same teacher was used in all classes and teacher influence was not being studied.

The Fennema-Sherman test uses a Likert scale wherein the subject responds, on a scale of 1 to 5, to their degree of agreement with a statement. The response choices range from strongly disagree (1 point), disagree (2 points), cannot decide (3 points), agree (4 points), and strongly agree (5 points). Each domain scale consists of 12 statements, 6 worded positively and 6 worded negatively. A score of 5 is given to the response that is hypothesized to have a more positive relation to learning mathematics. Scores of each domain scale, and the cumulative score of all domains, indicate student attitudes toward learning mathematics. A high score represents a positive attitude toward learning mathematics.

Split-half reliabilities of the Fennema-Sherman Attitude Test on 1600 middle-class, suburban/rural, grades nine through twelve, high school students showed the following values: Attitude towards Success (AS) 0.87; Confidence in Learning (C) 0.93; Effectance Motivation (E) 0.87; Usefulness (U) 0.88; and Anxiety (A) 0.89 (Fennema, 1976).

Fennema-Sherman (1976) established construct validity of the mathematics attitude scales by a principal components factor analysis. Although a correlation study between the scales showed some interrelation, each scale measured the construct it was designed to measure. The test may be given in any combination of scales for measurement of particular constructs.

Kolb Learning-Style Inventory

Kolb Learning-Style Inventory (LSI-IIa) purchased from McBer and Company was the test instrument chosen for classification of students according to preferred learning styles. The LSI-IIa requires students to answer twelve sentences about learning style by ranking four responses in the order they feel best describes how they learn. Scores are determined by assigning 4 points to the choice selected "as most like you" to 1 point for that rated as "least like you." The LSI-IIa is scored on a score sheet which groups the distinct learning stages into categories labeled: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The points of CE, RO, AC, and AE are plotted on the Cycle of Learning grid for a visual illustration of the student's mode of learning preferences. The student's learning style is determined on the Learning-Style Type Grid by plotting the values of AC-CE (perception dimension) versus AE-RO (transformation dimension). The quadrant of interception of these two data points classifies the test taker as accommodator, converger, assimilator or diverger.

Kolb's instrument was selected because it is a widely used test instrument in education research and it provides a means of relating this research to other studies. It was also selected because it provides a profile of student information processing in abstract versus concrete modes and in reflective versus active experimentation modes. Problem posing may be considered to be a creative task; evaluation of subjects by Kolb's Learning Style Inventory provides insight into this trait in measurement of divergent learning characteristics of students. The act of problem posing provides students with a means of experiencing mathematics in a personal dimension; this activity matches the basis of Kolb's theory of experiential learning.

Research by Veres (1991) provides reliability and validity information on the LSI-IIa test instrument. Internal consistency indices were determined on an initial study of 763 men and women and on a replication study of 1115 men and women. The ages of the subjects in both groups ranged from 17 to 63 years, with a mean age of 28 for the initial study and mean age of 26 for the replication study. In both studies, the LSI-IIa was administered three times with eight week interval spaces. Internal-consistency estimates showed mean coefficient alphas ranging from 0.52 to 0.71 for the initial sample and from 0.56 to 0.78 for the replication study. Test-retest reliabilities for LSI-IIa were calculated by computing zero-order correlation coefficients for subjects over three test administrations. Very high values were found with a range of 0.92 to 0.97 for the initial study and a range of 0.97 to 0.99 for the replication study. Kappa coefficients from test 1 to 2, test 1 to 3, and test 2 to 3 were 0.81, 0.71 and 0.86 respectively for the initial study and 0.91, 0.56, and 0.93 for the replication study. These high kappa coefficients signify the number of subjects changing learning style classification from one testing to another to be quite low. Veres concluded that LSI-IIa is a valid instrument in evaluating learning styles and recommended its use.

Mathematics Achievement Test

Student mathematics achievement gain was determined by subtracting pre-treatment and post-treatment achievement test scores. The achievement test instrument was the Walters State Community College final examination for MATH-0710. This final examination was based on the final examination, Form A, offered by the textbook author (Hughes & Yoshiwara, 1997); the examination reflected course content validity. Since this test is currently used in MATH-0710, a copy of the test could not be provided in this document.

The pre-treatment mathematics achievement test was the MATH-0710 final examination for the Summer, 1997, semester; the post-treatment achievement test was the MATH-0710 final examination for Fall, 1997. The summer and fall examinations were the same, with the exception of three questions. These three questions were omitted from both the pre-test and post-test yielding identical treatment achievement tests. Five multiple choice answers were provided per question; one choice listed on all problems was that the correct answer was not available.

Hypotheses

To achieve the purpose of the study, the following null hypotheses were tested at a 0.05 level of significance:

> H_1: There will be no significant difference between algebraic achievement scores of traditionally instructed students versus problem posing instructed students based on learning style classification and initial mathematics attitude.

> H_2: There will be no significant difference between pre-instruction mathematics attitude scores and post-instruction mathematics attitude scores of traditionally instructed students versus problem posing instructed students.

Data Analyses

The Statistical Package for Social Sciences (SPSS) was used for data analyses. Statistical analysis of the two study groups describing learning style types by percent was generated. Mean and standard deviation scores of the achievement pre-test and post-test were calculated for control and treatment groups. An independent samples t-test was performed to compare the mathematics achievement levels of the control and treatment groups.

Hypothesis 1 concerning mathematical achievement gain was analyzed by factorial analysis of variance using factors of instructional group and learning style classification with pre-attitude as a covariate. Learning styles were grouped twice for two separate analyses of variance studies: (1) according to ways of perceiving new information and (2) according to ways of processing information. Ways of perceiving new information separated learners as concrete experience or abstract conceptualization learners. Ways of processing information separated learners as active experimentation or reflective observational learners.

Hypothesis 2, which studied change in mathematics attitudes during the semester of treatment, was analyzed by repeated measures analysis of variance using factors of instruction group and learning style; pre-test and post-test attitude scores were the repeated measures over time.

Decisions to reject, or fail to reject, the hypotheses were based on statistical analysis at the 0.05 level of significance. Profile plots and additional t-tests were used when needed in the analysis. Results of the study are displayed in tables and figures in Chapter 4 and in Appendix F.

SUMMARY

This study involved students enrolled in a remedial algebra course at Walters State Community College during the fall semester of 1997. From 91 students enrolled in MATH-0710, a control group of 45 students and a problem posing treatment group of 46 students were analyzed. Students in the treatment group were instructed using a traditional lecture class with incorporation of problem posing activities; students in the control group were instructed by traditional lecture. Problem posing activities were employed for about one-third of each class meeting time.

Participants in the study were pre-tested and post-tested with five attitude domains of the Fennema-Sherman Mathematics Attitude Scales and with the final examination given by the College for the course, MATH-0710. Participants were tested at the beginning of the study with Kolb's Learning-Style Inventory (LSI-IIa) to obtain learning style classifications. Learning style was assumed to be a stable trait over the time period of one semester, therefore no post-test of learning style was given at the end of the study.

Test data were statistically analyzed with SPSS software to generate information about the population and form conclusions about the hypotheses of the study. Groups were described by learning style percentages. Mean and standard deviation scores of the achievement pre-test were calculated for control and treatment groups. An independent samples t-test was used to compare scores of control and treatment groups to confirm equality of groups. A 2-way ANOVA on pre-test achievement scores was used to confirm the equality of sub-groupings of concrete and abstract learners.

The first hypothesis claimed that no significant difference existed in the algebraic achievement gain of traditionally instructed students versus problem posing instructed students based on student learning styles and initial mathematics attitudes. To test this hypothesis, an analysis of variance, with a dependent variable of achievement, was performed for factors of treatment versus control group membership and for concrete versus abstract learning mode classification. The initial mathematics attitude of all subjects was examined as a covariate in this analysis of variance.

The second hypothesis claimed that no significant difference occurred in mathematics attitudes changes during the study for traditionally instructed students versus problem posing instructed students. To test this hypothesis, a general linear model of repeated measures was used for each of the five attitude domains tested. Pre-attitude and post-attitude scores served as repeated measures over time. Student attitude changes were analyzed according to treatment group membership and learning style classification.

Profile plots, tables, and figures were used for display of analysis results. Conclusions based on the findings of the study were made; recommendations for effective use of problems posing instruction and for future research in this area were also made.

CHAPTER IV

RESULTS

INTRODUCTION

The purpose of this study was to obtain information for effective use of problem posing instruction with remedial algebra mathematics classes. Information was sought concerning relationships of cognitive learning styles, algebraic achievement, and mathematics attitudes. To collect data, six classes of remedial algebra students during the Fall, 1997 semester, at Walters State Community College in Morristown, Tennessee were involved in a study. Three of the classes were taught using a traditional lecture method and three classes were taught using problem posing activities in addition to the traditional lecture method. The researcher taught all classes.

The students received Kolb's Learning-Style Inventory (LSI-IIa) at the beginning of the semester to establish their learning style preference. All students were pre-tested and post-tested with five domains of the Fennema-Sherman Mathematics Attitudes Scales. Achievement gain was determined from pre-test and post-test scores of the final examination for the course, MATH-0710.

Two null hypotheses concerning relationships of cognitive learning styles and mathematics attitude and achievement in a problem posing classroom were formulated and tested at the 0.05 level of significance using SPSS software. Hypothesis 1, pertaining to mathematical achievement gain, was analyzed by factorial analysis of variance using factors of instructional group and learning style classification with pre-attitude as a covariate. Hypothesis 2, which studied change in mathematics attitudes during the semester of treatment, was analyzed by separate repeated measures analysis of variance for each attitude domain tested. Factors of instruction group and learning style were used with pre-test and post-test attitude scores serving as repeated measures over time.

Hypothesis 1

> H_1: There will be no significant difference between algebraic achievement scores of traditionally instructed students versus problem posing instructed students based on learning style classification and initial mathematics attitude.

Data Analysis

The study initially consisted of 132 students of which 91 completed all instruments of the study. The control group initially consisted of 68 students of which 45 completed the study, and the treatment group initially consisted of 64 students of which 46 completed the study. All learning styles were represented in both the control and experimental groups. The converger learning style represented the smallest learning style body in both control and experimental groups. See Table 1 for a percentage description of control and treatment groups according to student learning style representation. Raw data for the study is provided in Appendix E.

Table 1. Description of Control and Treatment Groups by Learning Style.

			Treatment Group		
			Control	Problem Posing	Total
Learning Style Group	Accommodator	Count	10	13	23[a]
		% within GRP	22.2%	28.3%	25.3%[a]
	Assimilator	Count	20	12	32
		% within GRP	44.4%	26.1%	35.2%
	Converger	Count	3	5	8
		% within GRP	6.7%	10.9%	8.8%
	Diverger	Count	12	16	28
		% within GRP	26.7%	34.8%	30.8%
Total		Count	45	46	91
		% within GRP	100.0%	100.0%	100.0%

a. Pearson Chi-Square=3.452, df=3, p=.327

Group Analysis

Control and treatment groups were pre-tested during the first weeks of the semester with the College final examination for MATH-0710. The mathematics pre-test consisted of 27 multiple choice questions. Five answer choices were provided for each question; one of the answer choices indicated the correct answer was not given. All students finished the test with ample time. The mean score for the control group was 8.4 with a standard deviation of 2.482; the mean score for the treatment group was 9.0 with a standard deviation of 3.242. An independent samples t-test on the mathematics pre-test scores showed no significant difference in mathematics achievement pre-test scores between the control and treatment groups ($t = -0.917$, $df = 89$, $p = 0.361$).

Control and treatment groups were post-tested for mathematics achievement by repetition of the pre-test; this second testing served as the final examination for the MATH-0710 course. Achievement gain scores were determined by subtraction of pre-test scores from post-test scores. The mean achievement gain for the control group was 8.6 with standard deviation 4.207, and the mean achievement gain for the treatment group was 7.2 with standard deviation 4.102. No significant difference in achievement gain existed between the control and treatment groups ($t = 1.612$, $df = 89$, $p = 0.110$).

Concrete versus Abstract Learners

Two data processing strategies were chosen for the analysis of learning style interactions with achievement gain. The low cell frequencies of converger learners in control and treatment groups made grouping of learning styles necessary. The first data processing strategy combined concrete experience learners into one group and their learning mode opposites, abstract conceptualization learners, into another group. The study population consisted of 51 concrete learners and 40 abstract learners; the control group contained 22 concrete learners and 23 abstract learners, and the treatment group contained 29 concrete learners and 17 abstract learners. A Pearson chi-square test confirmed no relationship between concrete-abstract learning mode classification and control-treatment group membership ($t = 0.850$, $df = 1$, $p = 0.174$). A 2-way ANOVA showed no difference in pre-test achievement scores for any groupings of concrete versus abstract learning modes and treatment assignment ($F(3,87)=0.803$, $p=0.496$).

An analysis of variance for mean achievement gain was performed with factors of learning mode and treatment group membership and a covariate of pre-attitude toward mathematics; there was a significant interaction effect of learning mode and treatments ($p = 0.033$). The achievement gain profile plot relating learning mode and treatment group supported this interaction. Abstract learners in the problem posing treatment group showed the lowest achievement gain in all four categories as shown by Figure 3.

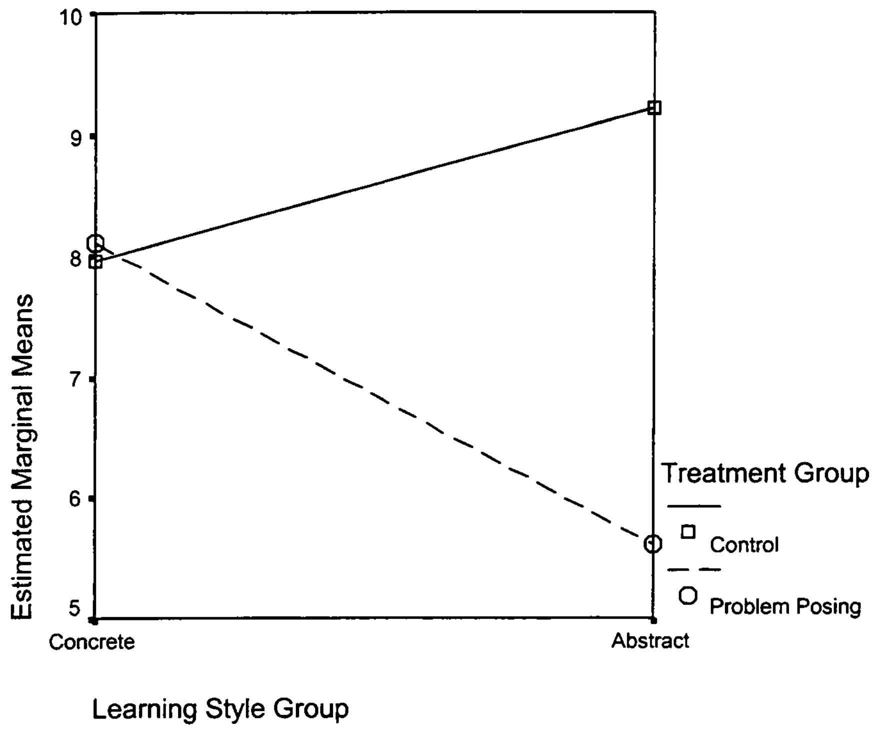


Figure 3. Plot of the Marginal Means for Achievement Gain.

Post-hoc independent samples t-tests, for equality of mean achievement gain between control and treatment groups for each learning mode, were performed. Abstract learners in the treatment group showed significantly lower achievement gain than abstract learners in the control group ($t = 2.408$, $df = 38$, $p = 0.021$). Concrete learners in control and treatment groups showed no significant difference in achievement gain ($t = -0.085$, $df = 49$, $p = 0.933$).

Within the problem posing treatment group, concrete learners showed a mean achievement gain of 8.0 and the abstract learners showed a 5.8 mean achievement gain. An independent samples t-test for these groups showed no significant difference in achievement gain for concrete versus abstract learners at the 0.05 level of significance ($t = 1.778$, $df = 44$, $p = 0.082$). At the 0.10 level of significance, a significant difference in achievement gain would be reported between concrete and abstract learners in a problem posing classroom.

Students were pre-tested with five domains of the Fennema-Sherman Mathematics Attitudes Scales. The sum of the five attitude tests was used as a covariate in the analysis of variance of achievement with factors of treatment group and learning style. Student pre-attitude toward mathematics showed no effect on achievement gain of concrete or abstract learners during the study ($p = 0.107$).

Reflective-Active Learners

The second data processing strategy for learning style interaction analysis sorted active experimentation learners versus their learning mode opposites reflective observational learners. The population consisted of 60 reflective learners and 31 active learners. The control group contained 32 reflective learners and 13 active learners; the treatment group contained 28 reflective learners and 18 active learners. A Pearson chi-square test showed no relationship between reflective-active learning style classification and control-treatment group membership ($t = 1.062$, $df = 1$, $p = 0.303$).

Achievement gain was studied by analysis of variance using learning mode and group membership as factors and attitude as a covariate. No significant effects were found for learning mode ($p = 0.291$) or group placement ($p = 0.221$). Pre-attitude data showed no effect on achievement gain ($p = 0.172$).

Hypothesis 1 Conclusion

Based on the finding that abstract conceptualization learners in the treatment group performed at a significantly lower achievement level than abstract conceptualization learners in the control group, hypothesis one is rejected.

HYPOTHESIS 2

> H_2: There will be no significant difference between pre-instruction mathematics attitude scores and post-instruction mathematics attitude scores of traditionally instructed students versus problem posing instructed students.

Data Analysis

Procedure

The Fennema-Sherman Mathematics Attitudes Scales for five domains was administered. The domain scales tested were Effectance, Mathematics Anxiety, Confidence, Usefulness, and Attitude toward Success in mathematics. Analysis on each domain scale tested was conducted separately with the SPSS program; a general linear model of repeated measures analysis of variance was used. Pre-attitude and post-attitude scores served as repeated measures over time. Prior analysis of

Hypothesis 1 demonstrated a significant difference in achievement gain for abstract learners of the control and treatment groups. Attitude change for each domain, with respect to student classification as concrete or abstract learners, was therefore examined. The analysis of variance factors were learning mode and treatment group. Attitude profile plots and post-hoc independent samples t-tests were performed when interaction was observed. Attitude statistical analyses are provided in Table 6 through Table 15 in Appendix F.

<u>Effectance Motivation Scale</u>

A repeated measures analysis of variance showed no significant effect of time, treatment group, or learning mode.

<u>Mathematics Anxiety Scale</u>

A repeated measures analysis of variance for mathematics anxiety showed significant interaction of time, treatment group, and learning mode ($p = 0.017$).

The Fennema-Sherman Mathematics Anxiety Scales is scored such that a high score indicates feelings of ease and a low score indicates feelings of anxiety. The profile plots of estimated marginal means of anxiety change showed increasing feelings of ease for concrete learners in control and treatment groups. Abstract learners in the control group experienced improvement in anxiety, but abstract learners in the treatment group showed no change in anxiety feelings. These observations are further studied using t-tests.

Independent samples t-test, comparing anxiety change of concrete learners in control and treatment groups (Figure 4), showed no significant difference between group membership ($t = -0.304$, $df = 49$, $p = 0.762$), but significant improvement occurred during the semester for concrete learners in both the control and treatment groups ($t = -2.428$, $df = 50$, $p = 0.019$). Independent samples t-test for abstract learners in control and treatment groups showed a significant attitude difference occurred ($t = 3.226$, $df = 38$, $p = 0.003$) (Figure 5).

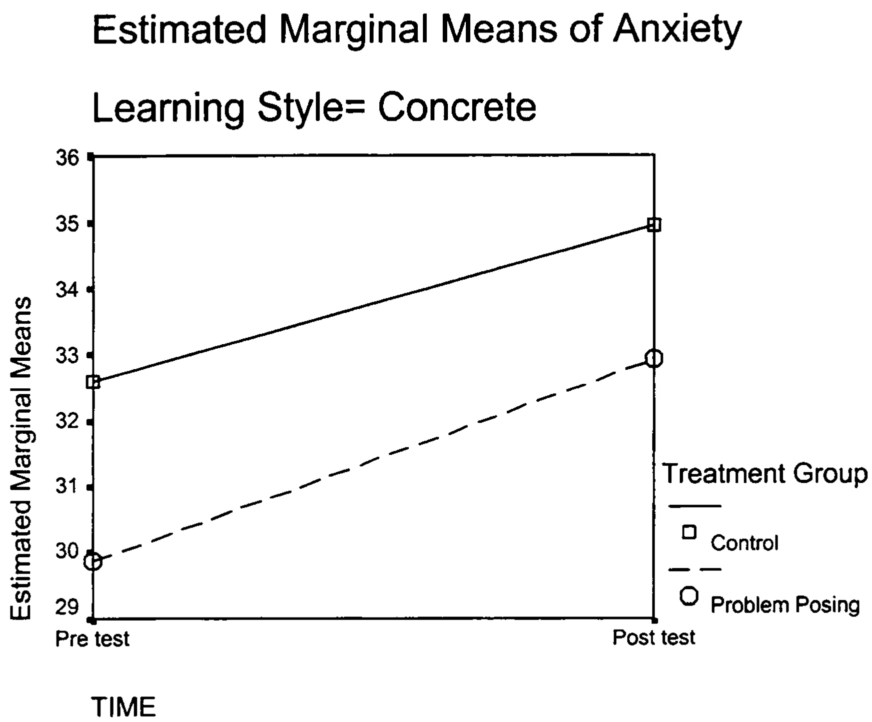


Figure 4. Anxiety of Concrete Learners.

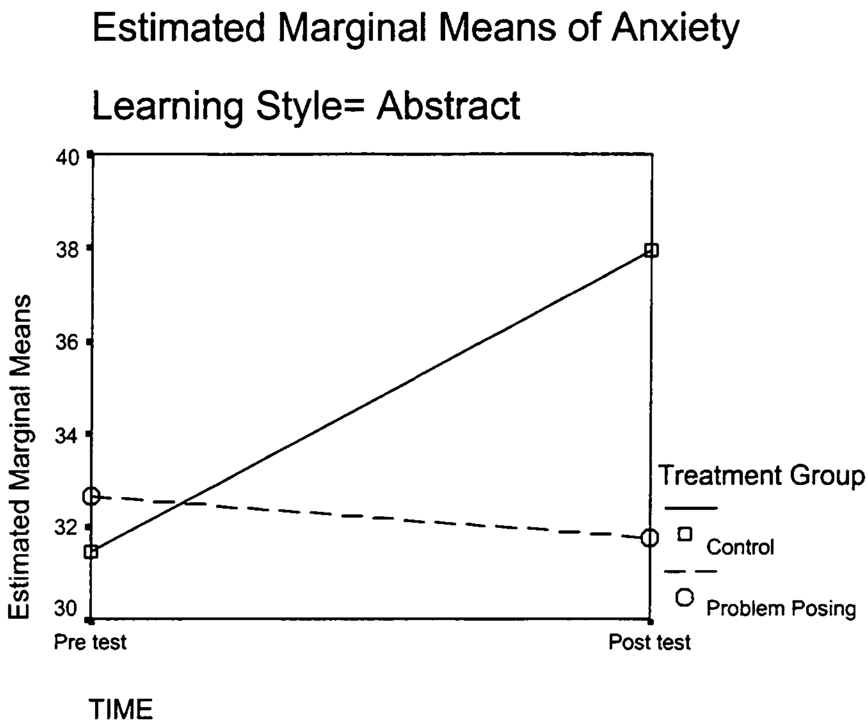


Figure 5. Anxiety of Abstract Learners.

Abstract learners in the treatment group did not fare as well as abstract learners in the control group. A paired samples t-test for abstract learners, within the problem posing treatment group, showed no significant difference in anxiety attitude change ($t = 0.540$, $df = 16$, $p = 0.597$); a paired samples t-test for abstract learners, within the control group, showed a significant improvement in anxiety change ($t = -4.193$, $df = 22$, $p < 0.001$).

Confidence in Learning Mathematics

A repeated measures analysis of variance showed significant interaction of time, treatment group and learning style ($p = 0.037$). The profile plots of estimated marginal means of confidence in learning mathematics showed concrete learners in the control and treatment groups and abstract learners in the control group increased in confidence in doing mathematics over time. Abstract learners in the treatment group showed a decrease in confidence in learning mathematics over time. The profile plots for concrete and abstract learners are shown as Figures 6 and 7.

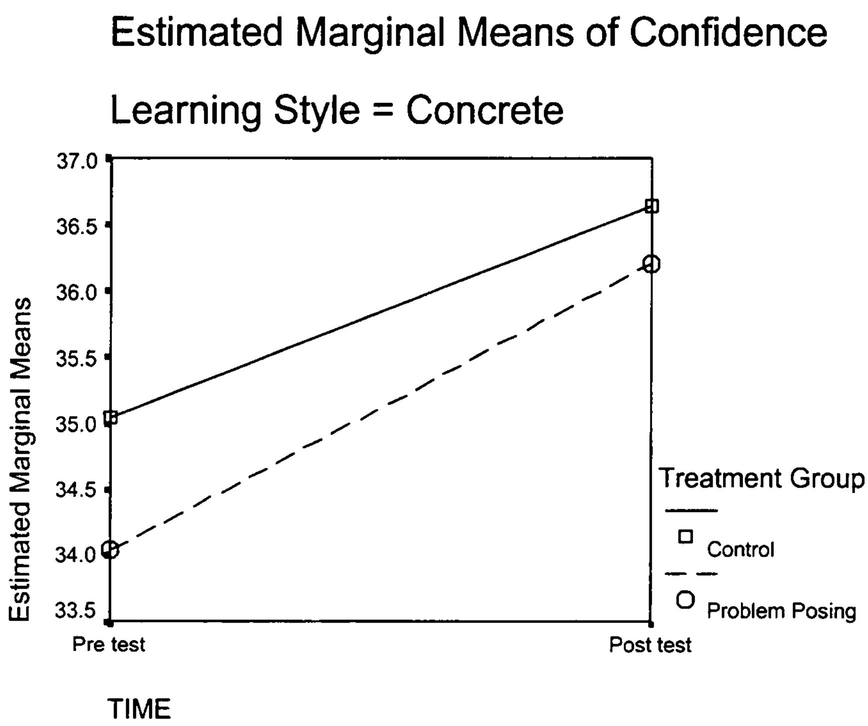


Figure 6. Confidence in Learning Mathematics for Concrete Learners.

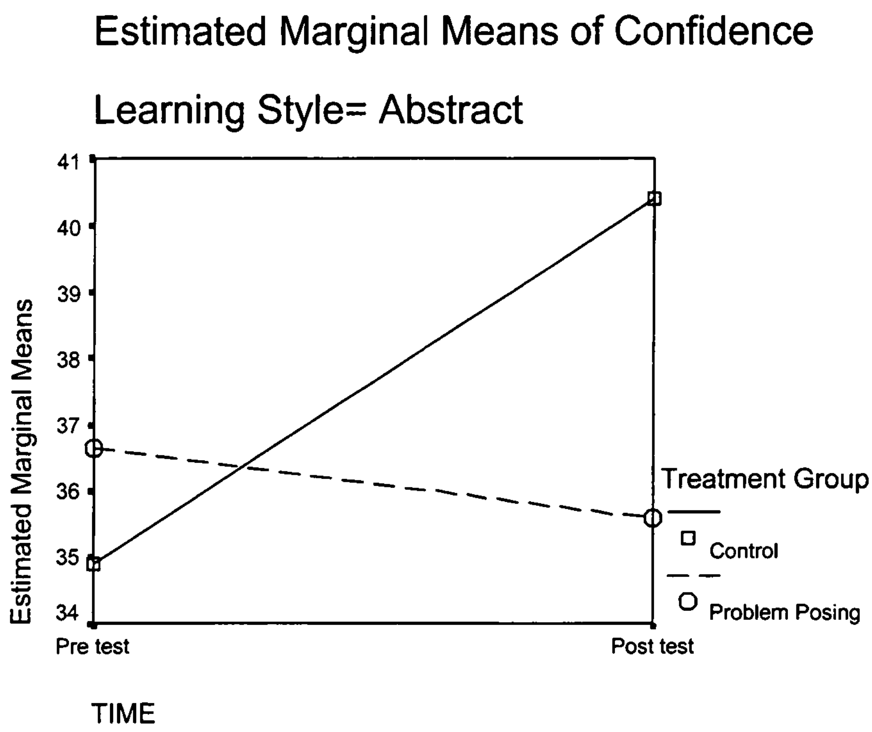


Figure 7. Confidence in Learning Mathematics for Abstract Learners.

Independent samples t-tests for concrete learners in control and treatment groups showed no significant difference in their gain in confidence in doing mathematics ($t = -0.252$, $df = 49$, $p = 0.802$). Independent samples t-test for abstract learners in control and treatment groups showed a significant difference occurred in mathematics confidence ($t = 2.707$, $df = 38$, $p = 0.010$). A paired samples t-test for abstract learners within the problem posing treatment group showed no significant change in confidence in doing mathematics ($t = 0.711$, $df = 16$, $p = 0.487$). Concrete learners in control and treatment groups showed no significant improvement in confidence in mathematics ($t = -1.7$, $df = 50$, $p = 0.095$). Abstract learners in the control group showed significant improvement in confidence in mathematics during the study ($t = -3.116$, $df = 22$, $p = 0.005$).

Mathematics Usefulness Scale

A repeated measures analysis of variance showed only a significant difference between learning style groups ($p = 0.025$). An estimated marginal means showed the mean for concrete learners at 44.744 and the mean for abstract learners at 47.857. This showed abstract learners considered mathematics more useful overall than did concrete learners.

Attitude Toward Success in Mathematics (AS)

A repeated measures analysis of variance showed no significant effect of time, treatment group, or learning style.

Hypothesis 2 Conclusion

Hypothesis 2 is rejected based on the findings of a significant difference in attitude change for abstract learners in the treatment group in the attitude domains of anxiety toward mathematics and confidence in doing mathematics.

SUMMARY

The relationships of cognitive learning styles, mathematics attitudes, and mathematics achievement in classrooms instructed with problem posing lessons were analyzed. The population for the study was remedial algebra students in MATH-0710 at Walters State Community College in Morristown, Tennessee. Cognitive learning styles were determined by Kolb's Learning-Style Inventory (LSI-IIa); mathematics attitudes were tested with five domains of the Fennema-Sherman Mathematics Attitudes Scales; mathematics achievement scores were obtained from the final examination of the course MATH-0710.

Two hypotheses were researched and tested in the study. Hypothesis 1, stating there is no significant difference between algebraic achievement scores of traditionally instructed students versus problem posing instructed students based on learning style classification and initial mathematics attitude, was rejected. Abstract conceptualization learners when instructed with problem posing lessons performed at a significantly lower achievement level than abstract learners instructed traditionally. The mathematics pre-attitude scores of control and treatment groups showed no significant effect on mathematics achievement gain.

Hypothesis 2, stating there will be no significant difference between pre-instruction mathematics attitude scores and post-instruction mathematics attitude scores of traditionally instructed students versus problem posing instructed students, was rejected. In the attitude domains of anxiety toward mathematics and confidence in learning mathematics, abstract learners in the treatment group performed at a significantly lower level than concrete learners of the same group.

The study demonstrated that abstract conceptualization learners did not perform as well when instructed with problem posing lessons as they did when instructed with traditional lessons. Abstract learners in the problem posing treatment showed significantly lower achievement gain, less improvement in anxiety feelings and less increase in confidence in learning mathematics. This finding was unlike concrete learners in the problem posing treatment who showed no difference from the control group in these areas. Although the study did not show all learners benefiting at the same rate in mathematics achievement with problem posing instruction, it did not show any group performing at a lower mathematics achievement level than at the beginning of the study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

INTRODUCTION

The primary problem in this study was to investigate the relationships between student learning style, mathematics attitude, and mathematics achievement gain for remedial algebra, community college students in a classroom employing problem posing instruction. The purpose of the study was to obtain information which would guide instructors in the effective use of problem posing instruction with these students. To achieve this purpose a quasi-experimental design was employed. Achievement scores and attitude toward mathematics scores for students who were taught with problem posing instruction were compared to scores of the control group. Student learning styles, as measured by Kolb's Learning-Style Inventory, were considered in the relationship of the method of instruction and its effect on student performance. A summary of the results of this study, along with conclusions and recommendations, are presented in the sections that follow.

SUMMARY

Six classes of remedial algebra, MATH-0710, at Walters State Community College in Morristown, Tennessee, were selected for the study. From these six classes, random selection of control and treatment groups, consisting of three classes each, was made. The study contained 91 subjects. There were 45 students in the control group and 46 students in the treatment group.

To accomplish the purpose of the study, two null hypotheses were formulated. Hypothesis 1 claimed there would be no significant difference in algebraic achievement gain of traditionally instructed students versus problem posing instructed students based on their learning style classification and initial mathematics attitude. Hypothesis 2 claimed there would be no significant change in mathematics attitudes of traditionally instructed students versus problem posing instructed students. The independent variable in the study was the use of problem posing treatment, and the dependent variables were mathematics attitude and mathematics achievement. Test instruments used were the Fennema-Sherman Mathematics Attitudes Scales, Kolb's Learning Style-Inventory (LSI-IIa) and the final examination for the pre-algebra course, MATH-0710.

Statistical Package for Social Sciences (SPSS) software was used for data analyses. A 0.05 level of significance was used in all tests. Hypothesis 1 was studied with a factorial analysis of variance using treatment group and learning style in regard to mathematics achievement gain; pre-attitude scores were analyzed as covariates in

this factorial analysis. Profile plots and post-hoc independent samples t-tests were applied when interaction was detected. Hypothesis 2 was studied by separate analyses of five attitude domains. A general linear model of repeated measures analysis of variance was used; five separate analyses were conducted with respect to treatment group membership, student learning style, and the repeated measure of attitude over time. The findings are provided in the following section.

SUMMARY OF THE FINDINGS

1. Abstract conceptualization learners in the problem posing treatment group performed with significantly lower achievement gain than did abstract learners in the control group. Hypothesis 1 was rejected.

2. Groups of both concrete experience and abstract conceptualization learners showed mathematics achievement gain during the semester.

3. Mathematics attitude of students at the beginning of the course had no significant effect on their achievement gain during the course.

4. Analysis of students, grouped in learning modes of reflective observational learners and active experimentation learners, showed

no significant effects for learning mode, group placement, or pre-attitude toward mathematics.

5. Concrete experience learners in both groups, and abstract conceptualization learners in the control group, showed increased feelings of ease or a lowering of mathematics anxiety; however, abstract conceptualization learners in the problem posing treatment group showed no change in mathematics anxiety feelings. Hypothesis 2 was rejected.

6. Concrete learners in both groups showed no significant gain in confidence. Abstract conceptualization learners in the control group showed increased feelings of confidence in learning mathematics; however, abstract conceptualization learners in the problem posing treatment group showed no change in confidence in learning mathematics.

7. From the study population, abstract conceptualization learners considered mathematics more useful overall than did concrete experience learners.

8. No significant effect of time, treatment group, or learning style was found in the attitude domains of effectance motivation and attitude toward success in mathematics.

Conclusions

The following conclusions were reached as a result of the findings presented in this study:

1. Abstract conceptualization students in this study learned mathematics with less achievement gain during the semester when using problem posing lessons than when instructed traditionally. This finding is consistent with predictions concerning abstract and concrete learners in problem posing situations. Abstract learners prefer assigned rules, lectures, readings, and deductive reasoning; concrete experience learners prefer lack of structure, brainstorming, and creative work (Kolb, 1984). The researcher concludes, that instructors using problem posing lessons, should provide students showing abstract learning traits, with extra assistance and guidance in problem posing lessons to maximize their achievement gain.

2. Abstract conceptualization learners experienced less improvement in the attitude domains of anxiety feelings and confidence in doing mathematics while instructed with problem posing lessons.

Discussion

During the study, the researcher found problem posing to be an instructional activity that was adaptable to many situations. Not only did problem posing fit well with most topics of the pre-algebra course, but it was useable with various teaching approaches. The researcher did not receive negative feedback on problem posing activities, in fact, most students seemed eager to write and solve their own problems.

The instructor found problems posed by students to offer an excellent window for viewing the student's achievement level in mathematics, spelling, and composition. Problems posed by the students early in the semester proved to be helpful to the instructor in getting to know the classes. In many cases, problems posed by individual students reflected their personal interests in sports, cars, and shopping. The instructor found problem posing to reveal as much about student understanding of basic concepts as examinations did.

In the study, abstract learners in the problem posing treatment group did not fare as well in achievement gain as abstract learners in a traditionally instructed class. Concrete learners in the treatment group, however, did not experience lower achievement gain than concrete learners in the control group. This may have resulted from the concrete learner's strengths in creativity, brainstorming, and risk-taking. Abstract learners have strength in deductive reasoning and solving problems presented to them. They prefer an organized approach to learning. The factors of an organized approach as opposed to a freer approach to learning may have influenced the achievement differences in these styles of learners.

Problem posing is a new activity for most students. Problems are usually obtained from a textbook or given by the teacher with no mention of how they were generated. Students need the experience of thinking through problem formulation. When a student enters his future workplace, problems will not be formed for him in advance with all variables taken into account and clearly delineated. Problems must be posed by the individual worker himself or in concert with his co-workers. Problem posing activities afford students an opportunity to learn and practice this valuable skill.

RECOMMENDATIONS

Based on the results and experiences of the study, recommendations for instruction with problem posing lessons and recommendations for further research in this area are given.

1. Instructors should be observant of changes in student performance with problem posing activities; particular notice should be paid to students having characteristics of abstract learners. It is recommended that students not performing well with problem posing instruction be offered extra assistance and guidance.

2. It is recommended that instructors provide positive reinforcement and encouragement to students during problem posing lessons. Instructors need to ask students how they feel about the problem posing activities, as well as, watch for silent feedback during instruction. Particular attention should be paid to students who have characteristics of abstract conceptualization learners.

3. It is recommended that this study be replicated with a population of students exhibiting a more equal distribution of Kolb's four learning styles. This would avoid regrouping of students as concrete or abstract learners.

4. This study was based on student learning styles as described by Kolb's experiential learning theory and tested with Kolb's Learning-Style Inventory (LSI-IIa). Since many learning style theories and test instruments exist, a similar study, with students characterized by different learning theories and test instruments, would broaden the scope of the effects of problem posing on learning. Additional research on this topic, applying different learning style models is recommended.

5. This study examined problem posing for remedial algebra community college students. Replication of this study is needed for students in higher level mathematics courses to determine how

they function is such an environment. Leung (1993) found subjects with greater mathematical knowledge to perform differently with problem posing tasks than subjects of lesser mathematical knowledge. Remedial level mathematics students have been found to prefer concrete experience learning, while college level students tend to prefer abstract conceptualization learning (Buchanan, 1992; Kristofco, 1991). To broaden educational knowledge about problem posing instruction, replication of this study is recommended using college level mathematics students.

6. All classes in this study were instructed by the researcher. Kolb's Learning-Style Inventory (LSI-IIa) showed her to learn in the modes of abstract conceptualization and active experimentation; she was a converger learner. This was the least represented learning style of the study population. It is possible that the learning style of the instructor had an effect on the way problem posing instruction was implemented and received by students. A replication of the study using instructors of other learning styles is recommended.

7. This study was conducted in a rather conservative, rural area of the country, eastern Tennessee. Perhaps different results would be

found in other parts of the country; students of a city or regions of more liberal thought might respond differently. Problem posing experiences may offer different results in culturally diverse groups (Silver, 1994). Additional studies of problem posing instruction are recommended using students of different demographic populations.

BIBLIOGRAPHY

Aiken, J., Lewis R., & Dreger, R. M. (1961). The effect of attitudes on performance in mathematics. *Journal of Educational Psychology, 52*, 19-24.

Altieri, G. (1987). *The problems and cognitive styles of adult learners.* Unpublished EdD Dissertation, Columbia University Teachers College.

American Mathematical Association of Two-Year Colleges (AMATYC). (1995). *Crossroads in mathematics: Standards for introductory college mathematics before calculus*. American Mathematical Association of Two-Year Colleges.

Axelson, S. L. (1992). Supermarket challenge. *Arithmetic Teacher, 40*, 84-88.

Balka, D. S. (1974). Creative ability in mathematics. *Arithmetic Teacher, 21*(7), 633-636.

Borba, M. C. (1994, April 4-8, 1994). *High school students' mathematical problem posing: An exploratory study in the classroom.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Brown, S. I., & Walter, M. I. (1983). *The art of problem posing* (1 ed.). Philadelphia, PA: Lawrence Erlbaum Associates.

Brown, S. I., & Walter, M. I. (1993). *Problem posing: Reflections and applications.* Hillsdale, NJ: Erlbaum.

Buchanan, L. K. (1992). *A comparative study of learning styles and math attitudes of remedial and college-level math students.* Unpublished EdD Dissertation, Texas Tech University.

Bush, W. S., & Fiala, A. (1986). Problem stories: A new twist on problem posing. *Arithmetic Teacher, 34*(4), 6-9.

Canfield, A. A. (1988). *Learning styles inventory manual.* Los Angles: Western Psychological Services.

Caskey, S. L. (1981). *A study of cognitive style and selected attribute variables of community college students.* Unpublished EdD Dissertation, Texas Tech University.

Claxton, C. S., & Ralston, Y. (1978). Learning Styles: Their impact on teaching and administration. *Eric Digest, 167 065.*

Cox, G. L. (1993). Identification of the at-risk mathematics student within the community college environment. *Dissertation Abstract International, 54-08A*, 2930.

Davis, J. F., Murrell, P. H., & Davis, T. M. (1988). *On matching teaching approach with student learning style: Are we asking the right question?* (ED 303 859). Louisville, Kentucky: Memphis State University.

Dillon, J. T. (1982). Problem finding and solving. *Journal of Creative Behavior, 16*, 97-111.

Dillon, J. T. (1988). Levels of problem finding vs. problem solving. *Questioning Exchange, 2*(2), 105-115.

Dunn, R., & Dunn, K. (1978). *Teaching students through their individual learning styles: A practical approach.* Reston, VA: Reston Publishing.

Elderveld, P. J. (1983). Factors related to success and failure in developmental mathematics in the community college. *Community Junior College Quarterly of Research and Practice, 7*(2), 161-174.

Ellerton, N. F. (1986). Children's made-up mathematics problems-A new perspective on talented mathematicians. *Educational Studies in Mathematics, 17*(1986), 261-271.

English, L. D. (1998). Children's problem posing within formal and informal context. *Journal for Research in Mathematics Education, 29*(1), 83-106.

English, L. D., & Halford, G. S. (1995). *Mathematics education: Models and processes.* Hillsdale, NJ: Erlbaum.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *JSAS Catalog of Selected Documents in Psychology, 6*(31), (MS. No. 1225).

Fisher, J. (1993). What's in the pot? *Mathematics Teacher, 86*(3), 214-215.

Friel, J. O., & Gannon, G. E. (1995). "What if...?" A case in point. *Mathematics Teacher, 88*, 320-322.

Gadanidis, G. (1994). Deconstructing constructivism. *Mathematics Teacher, 87*(2), 91-97.

Gage, M. S. (1982). *A comparison of forming and solving original mathematics word problems with solving ready made problems by community college students.* Unpublished PhD Dissertation, New York University, New York.

Getzels, J. W. (1975). Problem-finding and the inventiveness of solutions. *Journal of Creative Behavior, 9*(1), 12-18.

Getzels, J. W., & Csikszentmihalyi, M. (1962). *Creativity and intelligence: exploration with gifted students*. New York: Wiley.

Gonzales, N. A. (1996). Active participation in the classroom through creative problem generation. *The Mathematics Teacher, 89*(5), 383-385.

Harland-White, F. A. (1993). *Learning style as a correlate to course grade for a sample of students enrolled in community college telecourses.* Unpublished PhD Dissertation, The American University.

Hart, L. E. (1989). Describing the affective domain: Saying what we mean. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 37-45). New York: Springer-Verlag.

Hashimoto, Y. (1987). Classroom practice of problem solving in Japanese elementary schools. In J. B. T. Miwa (Ed.), *Proceedings of the U. S.-Japan seminar on mathematical problem solving* (pp. 94-119). Carbondale, IL: Southern Illinois University.

Haylock, D. W. (1987). A framework for assessing mathematical creativity in schoolchildren. *Educational Studies in Mathematics, 18*, 59-74.

Hickcox, L. K. (1990). *An Historical Review of Kolb's Formulation of Experiential Learning Theory.* Unpublished EdD Dissertation, Oregon State University.

Hinterthuer, R. J. (1984). *The relationship of developmental college students' learning styles to computer assisted and programmed instruction.* Unpublished EdD Dissertation, University of Arkansas.

Hughes, G., & Yoshiwara, K. (1997). *Instructor's Manual for Yoshiwara's Prealgebra.* Pacific Grove, CA: Brooks/Cole Publishing Company.

Jenkins, J. M. (1988). A learning style approach to effective instruction. In J. W. Keefe (Ed.), *Profiling and utilizing learning style* (pp. 41-45). Reston, VA: National Association of Secondary School Principals.

Joerger, R. M. (1992). *Relationships between the learning styles of students, instructors, and the programs of study of students in a selected Minnesota technical college and a selected Minnesota community college.* Unpublished PhD Dissertation, University of Minnesota.

Karrer, U. (1988). *Comparison of learning style inventories. (ERIC Document Reproduction Services No. ED 296 713*)

Keefe, J. W. (Ed.). (1979). *Student learning styles: Diagnosing and prescribing programs.* Reston, VA: National Association of Secondary School Principals.

Keefe, J. W. (Ed.). (1988). *Profiling and utilizing learning style.* Reston, Virginia: National Association of Secondary School Principals.

Keil, G. E. (1964). *Writing and solving original problems as a means of improving verbal arithmetic problem solving ability. Unpublished PhD Dissertation,* Indiana University.

Kilpatrick, J. (1987). Problem formulating: Where do good problems come from? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 123-147). Hillsdale, NJ: Erlbaum.

Kimball, R. L. (1991). Make your own problems-and then solve them. *Mathematics Teacher, 84*(8), 647-655.

Koenker, R. H. (1958). Twenty methods for improving problem solving. *Arithmetic Teacher, 5*, 74-78.

Kolb, D. A. (1984). *Experimental learning: Experience as the source of learning and development.* New Jersey: Prentice-Hall, Inc.

Kolb, D. A. (1993). *Learning style inventory.* Boston: McBer & Company.

Kristofco, J. P. (1991). The nonacademic differences between remedial and nonremedial students at a mid-size, urban community college. *Dissertation Abstract International, 51A*, 3610.

Krutetskii, V. A. (1976). *The psychology of mathematical abilities in school children.* Chicago: University of Chicago Press.

Leung, S. S. (1993). *The relation of mathematical knowledge and creative thinking to the mathematical problem posing of prospective elementary school teachers on tasks differing in numerical information content.* Unpublished PhD Dissertation, University of Pittsburgh, Pittsburgh.

Lindsey, L. B. (1987). *Learning style profiles of high school graduates and dropouts enrolled in North Carolina community colleges.* Unpublished EdD Dissertation, North Carolina State University.

Lodholz, R. D. (1980). *The effects of student composition on mathematical verbal problems on student problem solving performance.* Unpublished PhD Dissertation, University of Missouri-Columbia.

Lopez-Real, F. (1995). Generating real-life problems for the classroom. *Teaching Mathematics and its Applications, 14*(4), 156-162.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education, 28*(1), 26-47.

Matthews, D. B. (1991). The effects of learning style on grades of first-year college students. *Research in Higher Education, 32*(3), 253-267.

Moses, B. M., Bjork, E., & Goldenberg, E. P. (1990). Beyond problem solving: Problem posing. In T. J. Cooney (Ed.), *Teaching and learning mathematics in the 1990's* (pp. 82-91). Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (NCTM). (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA.

National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics*. Reston: National Council of Teachers of Mathematics.

Neale, D. C. (1969). The role of attitude in learning mathematics. *Arithmetic Teacher, 16*, 631-640.

O'Connell, S. R. (1995). Newspapers: Connecting the mathematics classroom to the world. *Teaching Children Mathematics* (January), 268-274.

Perez, J. A. (1985). *Effects of student-generated problems on problem solving performance.* Unpublished EdD Dissertation, Columbia University Teachers College.

Polya, G. (1957). *How to solve it* (2 ed.). New York: Doubleday.

Prichard, G. R. (1995). The NCTM standards and community colleges: Opportunities and challenges. *Community College Review, 23, no. 1*(Spring), 23-32.

Purkiss, W. F. (1994). *Learning styles and their relationship to academic success: A community college perspective.* Unpublished PhD Dissertation, The Claremont Graduate School.

Rives, B. S. (1992). A structural model of factors relating to success in calculus, college algebra and developmental mathematics. *Dissertation Abstract International, 53-09A*, 3134.

Romines, R. (1997). Personal communication, Spring, 1997.

Rule, D. L., & Grippin, P. C. (1988). A critical comparison of learning style instruments frequently used with adult learners. (Eric Document Reproduction Service No. *ED 305 387*, 24)

Schloemer, C. G. (1994). *Integrating problem posing into instruction in advanced algebra: feasibility and outcomes.* Unpublished EdD Dissertation, University of Pittsburgh.

Shelton, W. M. (1995). *Effects of an integrated learning system on students enrolled in college algebra in a community college.* Unpublished EdD Dissertation, Baylor University.

Silver, E. A. (1994). On mathematical problem posing. *For the Learning of Mathematics, 14*(1), 19-28.

Silver, E. A., & Adams, V. M. (1987). Using open-ended problems. *Arithmetic Teacher, 34*(May), 34-35.

Silver, E. A., & Cai, J. (1996). An analysis of arithmetic problem posing by middle school students. *Journal for Research in Mathematical Research, 27*(5), 521-539.

Silver, E. A., & Mamona, J. (1990). Stimulating problem posing in mathematics instruction through open problems and "what-if-nots". In G. W. Blume & M. K. Hwid (Eds.), *Implementing new curriculum and evaluation standards: 1990 Yearbook* (pp. 1-7): Pennsylvania Council of Teachers of Mathematics.

Silverman, F. L., Winograd, K., & Strohauer, D. (1992). Student-generated story problems. *Arithmetic Teacher, 39*(8), 5-12.

Smith, D. M., & Kolb, D. A. (1996). *User's guide for the learning-style inventory.* Boston: McBer & Company.

Van Den Brink, J. (1987). Children as arithmetic book authors. *For the Learning of Mathematics, 7*(2), 44-47.

Van Horn, C. M. (1994). *Effects of using the writing process in combination with traditional problem-solving instruction.* Unpublished MS Thesis, University of Houston-Clear Lake.

Veres, J. G., Sims, R. R., & Locklear, T. S. (1991). Improving the reliability of Kolb's revised learning style inventory. *Educational and Psychological Measurement, 51*, 143-147.

Wakefield, J. F. (1991). The outlook for creativity tests. *The Journal of Creative Behavior, 25*(3), 184-193.

Walters State Community College (WSCC), (1997). *Walters State, The Great Smoky Mountains Community College.* (Vol. 1). Morristown, TN: Walters State Community College.

Williams, S. M. (1994). *Anchored simulations: Merging the strengths of formal and informal reasoning in a computer-based learning environment.* Unpublished Ph.D Dissertation, Vanderbilt University, Nashville, TN.

Winograd, K. (1990). *Writing, solving, and sharing original math story problems: Case studies of fifth grade children's cognitive behavior.* Unpublished EdD Dissertation, University of Northern Colorado, Greeley, Colorado.

Yoshiwara, K. (1997). *Prealgebra.* Pacific Grove, California: Brooks/Cole.

APPENDICES

APPENDIX A

COPYRIGHT PERMISSION

Hay McBer
116 Huntington Avenue
Boston, MA 02116-5712
Tel: (617) 437-7933
Fax: (617) 425-0073

Hay McBer15 July 1998

Mary Owens
PO Box 909
White Pine, TN 37890

Dear Ms. Owens:

You may have permission to include in your dissertation one copy of the two charts from the Learning Style Inventory IIA, the "Comparison of the Learning Style with Problem-Solving Skills" and the chart on page 11 of the complete booklet. Please include our copyright on each page:

© Experience-Based Learning Systems, Inc., 1993. Developed by David A. Kolb. Reproduced with permission from McBer & Company, Inc., 116 Huntington Avenue, Boston, MA, 02116.

Thanks,

Krista Jones
Senior Customer Service & Sales Representative

Krista E. Jones

HayGroup

APPENDIX B

INFORMED CONSENT FORM

Student Informed Consent Form

During the Fall Semester, 1997, a teaching study will be conducted in Mathematics 0710 classes at Walters State Community College taught by Mrs. Owens. The study will examine the relationships of cognitive learning styles, mathematics attitude, and achievement in classrooms where students learn to compose and solve their own mathematics problems. You are enrolled in either a course section that will be taught by the traditional methods of instruction at WSCC, or you are enrolled in a course section that will use problem posing in addition to traditional methods. The data collected will be used to improve mathematics instruction and to complete Mrs. Owens' dissertation requirement for the Ph. D. degree. The risk involved in this study is minimal.

As a participant in the study, you will be asked to take the WSCC 0710 Final Examination and a mathematics attitudes scale test both at the beginning and end of the semester. You will also be asked to take the Learning Style Inventory test at the beginning of the semester. If you are a student in a problem posing group, you will be asked to do in-class exercises of forming and solving mathematics problems. At the end of the semester, you will be asked to complete a questionnaire concerning your reaction to the teaching strategy.

Information and data collected from students participating in the study will not influence course grades. Student identification will be coded and remain confidential, and statistical data will be reported as group data. The test data will be stored in private files of the researcher at her residential office.

If you should decide later not to participate in the study, you may withdraw at any time without prejudice. Withdrawal may be in writing or verbally to Mrs. Owens.

If you have any questions regarding this study, contact Mrs. Owens at the phone or office listed below.

Mary E. Owens
Life Science Building, Office 119
Walters State Community College
500 S. Davy Crockett Parkway
Morristown, Tennessee 37890
423-585-6935

You are making a decision whether or not to participate in the study described above. This is a voluntary decision. Your signature indicates that you have read the information and have agreed to participate.

Name: (please print)____

Social Security Number: ________________________

Signature: __________________________________ **Date:** __________

APPENDIX C

COURSE DESCRIPTION AND MATERIALS

WALTERS STATE COMMUNITY COLLEGE

COURSE SYLLABUS

COURSE: Basic Mathematics-MATH 0710

SEMESTER: Fall, 1997

INSTRUCTOR: Mrs. Mary Owens Office: LSCI

REQUIRED TEXTBOOK: PreAlgebra, by Katherine Yoshiwara

TI-83 graphing calculator is required for this course.
Discuss with instructor if you own another graphing calculator.

CATALOG DESCRIPTION:

A basic mathematics course designed to review computation with whole numbers, fractions, and decimals. Other topics include ratio and proportion, percent, elementary and descriptive statistics, basic geometry, and an introduction to algebra. Satisfactory completion of this course allows the student to exit to Math 0820, Elementary Algebra. This course adds 3 credit hours to the graduation requirements for students enrolled. (Prerequisite: Admission is by the college assessment procedure only.)

3 Credits

PURPOSES:

1. To help the student build a solid foundation for the study of college mathematics.
2. To emphasize the beauty and purpose of mathematics.
3. To help the student understand the language of mathematics
4. To encourage the student to continue the study of mathematics.

COMPETENCIES:

1. Perform in proper order, the basic operations (addition, subtraction, multiplication, division) with whole numbers, fractions, decimals and signed numbers by hand and by using a calculator.
2. Solve application problems involving operations with whole numbers, fractions, decimals, and signed numbers.
3. Work with proportion and percent and solve applied problems.
4. Work with and understand the display of data and descriptive statistics.
5. Recognize simple geometric concepts and solve problems involving area and perimeter/circumference.
6. Understand and use a graphing calculator for problem solving.
7. Understand the concept of variable and write appropriate equations to model situations.
8. Solve and graph basic equations.

COURSE CONTENT:

Unit 1- Variables and Equations	
Lessons 1.1-1.10	Test 1 (Unit 1)
Unit 2- Signed Numbers: Order of Operations	
Lessons 2.1-2.13, 2.14A, 2.15A	Test 2 (Unit 2)
Unit 3- Exponents and Fractions	
Lessons 3.1-3.34A, 3.6-3.9	Test 3 (Unit 3)
Unit 4- Proportion and Percent; Graphing	
Lessons 4.1-4.3, 4.5, 4.6,4.8	Test 4 (Unit 4)
ATTENDANCE/HOMEWORK/QUIZZES	Test 5

ATTENDANCE AND CLASSROOM CONDUCT:

Attendance is required in Developmental Mathematics. Our purpose is to help you master the content of this course. Your instructor counts absences from the first scheduled meeting of the class and reports absences for financial aid and on the final grade reports. Good attendance is vital to success in this course. It is your responsibility to inform your instructor in advance of a planned absence and to make arrangements for make-up work.

EVALUATION METHOD:

Grading will be determined by tests covering the course material, a grade based on classwork, and a comprehensive final. Attendance, homework assignments, and/or quizzes will be evaluated and counted as one test grade. The final exam may count as much as 1/3 of the grade. To take a test in the Math Lab, a student must make prior arrangements with the instructor and show a valid WSCC student ID.

The college prohibits plagiarism, cheating, and other forms of academic dishonesty. If any student behaves in a disruptive manner, the instructor can order the student to leave the classroom for a period of time.

GRADING SCALE:

A = 90 - 100

B = 80 - 89

C = 70 - 79

F = 0 - 69

TWO ATTEMPT RULE Any student who attempts Math 0710 twice without a satisfactory grade will be denied admission to the college for one semester. A grade of "F" is unsatisfactory and a "W" counts as one attempt. After one semester the student may re-enroll in the required course.

Upon successful completion of Math 0710, the student will enroll in Math 0820-Elementary Algebra.

**Please take Math 0820 as soon as possible. Some students delay and forget what they have learned in Math 0710. However, state rules do not allow students to drop back and retake Math 0710 after they have passed the course.

Math 0710 Content by Topic Listing

Referenced to course textbook, Prealgebra by Katherine Yoshiwara (1995, pages vii-ix).

Unit 1

1. Variables
2. Algebraic Expressions
3. Evaluating Expressions
4. Writing Algebraic Expressions
5. Equations
6. Solving Equations
7. Area and Perimeter
8. Formulas
9. Geometric Formulas
10. Problem Solving with Equations

Unit 2

1. Negative Numbers
2. Addition of Signed Numbers
3. Subtraction of Signed Numbers
4. Multiplication and Division of Signed Numbers
5. Problem Solving with Equations and Negative Numbers
6. Order of Operations
7. Algebraic Expressions with Two Operations
8. Equations with Two Operations
9. Problem Solving with Formulas
10. Order of Operations with Signed Numbers

11. Equations Again
12. Graphs and Display of Data
13. Like Terms
14. Simplifying Expressions with the Distributive Law
15. Problem Solving using Algebraic Equation

Unit 3

1. Exponents
2. Order of Operations
3. Square Roots
4. Applications of Square Roots
5. Fractions
6. Multiplying and Dividing Fractions
7. Adding and Subtracting Fractions
8. Adding and Subtracting Unlike Fractions

Unit 4

1. Decimal Fractions and Percent
2. Percent Problems
3. Graphs and Equations
4. Ratio and Rates
5. Proportions
6. Problems Involving Interest

WORKSHEET 1 **Name** ____________________

ADDITION

I. Compute

a. (+5) + (+3) = _____ b. 13 + (-4) = ______ c. 3 + (-7) = ________

d. (-6) + (-10) = _____ e. (-28) + 30 = ______ d. -18 + 12 = _______

II. Write and solve problems to do the following. Check answers with a calculator.

a. Add two positive numbers. ________________________________

b. Add two negative numbers. ________________________________

c. Add one positive number and one negative number. ________________

SUBTRACTION

III. Compute

a. (+8) - (+3) = _____ b. (-5) - (-8) = ______ c. - 20 - (+10) = ______

d. 9 - (-2) = _______ e. -3 - 7 = _________ f. 18 - (-18) = ________

IV. Write and solve problems to do the following. Check answers with a calculator.

a. Subtract two positive numbers. ______________________________

b. Subtract two negative numbers.______________________________

c. Subtract a positive number from a negative number. ________________

d. Subtract a negative number from a positive number.________________

V. Write four addition problems that yield a negative number as an answer.

______________________ ______________________

______________________ ______________________

VI. Write four subtraction problems that yield a negative number as an answer.

______________________ ______________________

______________________ ______________________

MULTIPLICATION AND DIVISION

MULTIPLY

I. Compute

a. (6)(5) = ________ b. (-4)(-2) = ________ c. (8)(-10) = ________

d. 7(-4) = ________ e. (-2)(12) = ________ f. -6(3) = ________

II. Write multiplication problems to do the following. Check answers with a calculator.

a.. Multiply two numbers that have positive signs. ____________________

b. Multiply two numbers that have negative signs. ____________________

c. Multiply a positive number times a negative number. ____________________

DIVISION

III. Compute

a. $\frac{+6}{+3}$ = ________ b. $\frac{-4}{-2}$ = ________ c. $\frac{10}{-5}$ = ________

d. $\frac{+20}{-4}$ = ________ e. $\frac{-14}{-7}$ = ________ f. $\frac{0}{-9}$ = ________

IV. Write division problems to do the following. Check your answers with a calculator.

a. Divide two positive numbers. ____________________

b. Divide two negative numbers. ____________________

c. Divide a positive number by a negative number. ____________________

d. Divide a negative number by a positive number. ____________________

V. a. Write three *multiplication* problems that will give a negative answer.

________________ ________________ ________________

b. Write three *division* problems that will give a negative answer.

ORDER, ORDER !

The order of operations in mathematics says to first simplify within parenthesis, then do exponents or square roots, next do multiplication or division proceeding left to right, and finally do any additions or subtractions. The sentence "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally" helps us remember this order.

What might problems look like that need the following order of operations to occur in them?

1. Multiplication occurring before an addition. ______________________
   For Example: $2 + 8(-5)$ answer: -38

2. Multiplication before division. ______________________

3. Simplify parenthesis then division. ______________________

4. Exponent then multiplication by a -3. ______________________

5. Exponent followed by division then subtraction. ______________________

6. Six times a parenthesis being subtracted from 5.______________________

7. Parenthesis squared, followed by division, added to 9. ______________________

8. Exponents on two numbers that are being added. ______________________

9. Square root, followed by division, followed by multiplication. ______________

10. Exponents on two parenthesis being divided. ______________________

Review for Test: Unit Two Name____________________

Pages 183-186 is a chapter review. The odd problems are assigned for homework. After you do each section of the problems for homework, write three more problems of that type.

Make the first problem you write easy; the second problem harder; and the third problem even harder. Solve your problems.

I. (1-5) **Give an example of the type of number described:**

a. easy ____

b. harder ______________________________________

c. even harder __________________________________

II. (9) **Graph a set of positive and negative numbers on a number line.**

a. easy ____

b. harder ______________________________________

c. even harder __________________________________

III. (11) **Choose a variable for an unknown quantity and write an inequality.**

a. easy ____

b. harder ______________________________________

c. even harder __________________________________

IV. (13-23) **Write 3 true and false statements about algebraic operations.**

a. easy ____

b. harder ______________________________________

c. even harder __________________________________

V. (24-49) **Write expressions to simplify involving signed numbers.**

a. easy ______________________________

b. harder ______________________________

c. even harder ______________________________

VI. (51-59) **Evaluate expressions for given value of variables.**

a. easy ______________________________

b. harder ______________________________

c. even harder ______________________________

VII. (61-65) **Combine like terms.**

a. easy ______________________________

b. harder ______________________________

c. even harder ______________________________

VIII. (67-75) **Solve equations.**

a. easy ______________________________

b. harder ______________________________

c. even harder ______________________________

IX. (77-81) **Word Problems**

a. easy ______________________________

b. harder ______________________________

c. even harder ______________________________

MISSING DATA??

Supply the necessary information, then solve your problem.

1. James took 1200 steps in walking to school from home. How far did he live from home?

2. Nora studied her lessons 3 times as long as Margaret studied hers. How long did Nora study?

3. A pair of shoes on sale were marked down $25. What percent off was this price?

4. What is the area of a triangle whose base is 10 feet?

5. John sold his pigs for $275 and bought concert tickets to see Bob Dillion with the money. How many tickets did John buy?

6. If Ethel has $40 more than Lucy, how much money do they both have?

7. If an auto shop charges $20 to estimate the repair on a car plus $12.50 per hour for the work needed, how much is the bill on Mr. Petty's car?

8. There are five times as many boys as girls at the neighborhood Halloween Party. How many boy and girls were attending?

9. Suzy Qualls drove 458 miles on Monday to visit her friends. What was her rate in miles per hour for the trip?

10. The total number of points scored by the class on the French Final Exam was 738. What was the average grade on the examination?

WORD PROBLEMS MATH 0710

These problems were written by your fellow classmates recently.

1. **It was 1970 and I was standing on a corner in Winslow, Arizona, thinking...** *(This phrase was written on the board by the instructor.)*

   .....my cousin lives 200 miles away, I have $75 cash, my car gets 15 miles per gallon, and the speed limit is 75 mph.

   a. How much money will the trip to see my cousin cost if gas is $0.50 per gallon? How much will a round-trip cost? Will I have any money left over?

   b. If I travel at the speed limit of 75 miles per hour, with no stops, how long will it take me to reach my cousin's house?

   c. How many times will I have to stop for gas on a trip to my cousins, if the gas tank holds 20 gallons?

2. For a car moving 772 miles per hour,
   (a.) how far will it go in one minute?

   (b.) How long will it take it to go 300 miles?

3. At 52 miles per hour, a dirt bike runs the oval track. One lap takes 2 minutes. How long will it take the biker to run a 30 lap race?

4. There are 100 puppies without a home. Each puppy cost $25. If Lane bought $50 worth and Samantha bought $75 worth of puppies, how many puppies are left?

5. I am driving 75 miles per hour and it is 25 miles to Kyle's' house. If I have been driving for 5 minutes already, how much longer do I lack before I reach his house?

6. A football field is 100 yards, its width is 50 yards. If I ran 10 yards from side to side until I got to the end of the field, how many yards would I have run?

7. Profits has a 25% off sale on their $35.00 jeans. Wal-Mart's jeans are $23.50 every day. Who has the cheaper jeans?

8. How long will it take me to walk from the TECH building to my next class in LSCI? My next class starts at 9:05am and I'll be walking 2 miles per hour?

9. A man goes to Lowe's and buys 50, 8 foot long 2X4's at $3.00 a board. He wants to cover a 100 square foot area. What will be his Lowe's bill for the boards? How much can he cover?

10. Amy is 6 feet tall. At 4PM her shadow is 10 feet long. How tall is the playhouse in her backyard if its shadow is 38 feet long at 4PM?

11. If 20% of 3,000 people smoke, how many people will that be?

12. One cup of yeast is needed for 5 loaves of bread; how many cups are needed to make 35 loaves?

13. Nikkei made $100 for 1 hour washing cars as a fund raiser. How long will it take to make $1,000?

14. Stacey has a sample of 20 items and 2 are bad. If she ships 1000 items to a customer, how many would be expected to be bad?

15. It takes 10 days to build a 1200 square foot house. How long would it take to build a 2400 square foot house?

16. You walk into a shoe store which is having a sale on their Timberland boots. You see a pair that you like for $89.99 with 25% off that. You have $76.00 and the tax is 8.5%. Do you have enough money to buy the shoes?

APPENDIX D

ATTITUDE TEST

Fennema - Sherman Mathematics Attitudes Scales
Elizabeth Fennema - Julia A. Sherman
University of Wisconsin - Madison

Directions

There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice.

On the following pages are a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. Suppose the statement is:

Example: I like mathematics. A B C D E

As you read the statement, you will know whether you agree or disagree.

If you strongly agree, circle in **A.**

If you agree but with reservations, that is, you do not fully agree, circle **B.**

If you disagree with the idea, indicate the extent to which you disagree by circling **D** for disagree or circling **E** for strongly disagree.

If you neither agree nor disagree, that is, you are not certain, circle **C** for undecided.

If you cannot answer a question, circle **C.**

A = Strongly Agree

B = Agree

C = Not Certain or Cannot Answer

D = Disagree

E = Strongly Disagree

Statement	Circle Choice
1. I don't understand how some people can spend so much time on math and seem to enjoy it.	A B C D E
2. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	A B C D E
3. I usually have been at ease during math tests.	A B C D E
4. I am sure that I can learn mathematics.	A B C D E
5. Mathematics is enjoyable and stimulating to me.	A B C D E
6. For some reason even though I study, math seems unusually hard for me.	A B C D E
7. Figuring out mathematical problems does not appeal to me.	A B C D E
8. I get a sinking feeling when I think of trying hard math problems.	A B C D E
9. When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	A B C D E
10. I like math puzzles.	A B C D E
11. Math puzzles are boring.	A B C D E
12. Mathematics will not be important to me in my life's work.	A B C D E
13. People would think I was some kind of a grind if I got A's in math.	A B C D E
14. I don't like people to think I'm smart in math.	A B C D E
15. In terms of my adult life it is not important for me to do well in mathematics in high school.	A B C D E
16. Mathematics usually makes me feel uncomfortable and nervous.	A B C D E
17. Mathematics is of no relevance to my life.	A B C D E
18. Math has been my worst subject.	A B C D E
19. I'd be proud to be the outstanding student in math.	A B C D E
20. I do as little work in math as possible.	A B C D E

Statement	Circle Choice
21. I'll need a firm mastery of mathematics for my future work.	A B C D E
22. I have a lot of self-confidence when it comes to math.	A B C D E
23. I'm no good in math.	A B C D E
24. I don't think I could do advanced mathematics.	A B C D E
25. Math doesn't scare me at all.	A B C D E
26. I see mathematics as a subject I will rarely use in my daily life as an adult.	A B C D E
27. I will use mathematics in many ways as an adult.	A B C D E
28. If I got the highest grade in math I'd prefer no one knew.	A B C D E
29. It would make people like me less if I were a really good math student.	A B C D E
30. My mind goes blank and I am unable to think clearly when working mathematics.	A B C D E
31. I am sure I could do advanced work in mathematics.	A B C D E
32. Taking mathematics is a waste of time.	A B C D E
33. Once I start trying to work on a math puzzle, I find it hard to stop.	A B C D E
34. The challenge of math problems does not appeal to me.	A B C D E
35. It would make me happy to be recognized as an excellent student in mathematics.	A B C D E
36. I expect to have little use for mathematics when I get out of school.	A B C D E
37. It would be really great to win a prize in mathematics.	A B C D E
38. I'll need mathematics for my future work.	A B C D E
39. Mathematics makes me feel uneasy and confused.	A B C D E
40. I study mathematics because I know how useful it is.	A B C D E

Statement	Circle Choice
41. I would rather have someone give me the solution to a difficult math problem than to have to work it out ......for myself.	A B C D E
42. I'm not the type to do well in math.	A B C D E
43. Mathematics is a worthwhile and necessary subject.	A B C D E
44. I haven't usually worried about being able to solve math problems.	A B C D E
45. I'd be happy to get top grades in mathematics.	A B C D E
46. I can get good grades in mathematics.	A B C D E
47. Being first in a mathematics competition would make me pleased.	A B C D E
48. I almost never have gotten shook up during a math test.	A B C D E
49. When a question is left unanswered in math class, I continue to think about it afterward.	A B C D E
50. I think I could handle more difficult mathematics.	A B C D E
51. Knowing mathematics will help me earn a living.	A B C D E
52. Winning a prize in mathematics would make me feel unpleasantly conspicuous.	A B C D E
53. I usually have been at ease in math classes.	A B C D E
54. It wouldn't bother me at all to take more math courses.	A B C D E
55. A math test would scare me.	A B C D E
56. I am challenged by math problems I can't understand immediately.	A B C D E
57. Being regarded as smart in mathematics would be a great thing.	A B C D E
58. If I had good grades in math, I would try to hide it.	A B C D E
59. Most subjects I can handle O.K., but I have a knack for flubbing up math.	A B C D E
60. Generally I have felt secure about attempting mathematics.	A B C D E

APPENDIX E

RAW DATA

Table 2. Achievement and Learning Style Scores for the Control Group.

Control Group Scores

Control Student	Achievement			Learning Style						
	Pre	Post	Net	Concrete Experience (CE)	Reflective Observation (RO)	Abstract Conceptual-ization (AC)	Active Experiment-ation (AE)	(AC)-(CE)	(AE)-(RO)	Learning Style
1	9	16	7	32	25	28	35	-4	10	Accommodator
2	6	9	3	29	24	32	35	3	11	Accommodator
3	9	11	2	29	27	26	38	-3	11	Accommodator
4	7	23	16	27	25	28	40	1	15	Accommodator
5	8	13	5	26	29	23	42	-3	13	Accommodator
6	7	14	7	30	29	26	35	-4	6	Accommodator
7	8	11	3	32	29	24	35	-8	6	Accommodator
8	11	13	2	33	25	24	38	-9	13	Accommodator
9	7	19	12	30	29	25	36	-5	7	Accommodator
10	8	22	14	25	33	23	39	-2	6	Accommodator
11	9	16	7	18	35	28	39	10	4	Assimilator
12	8	14	6	23	30	42	25	19	-5	Assimilator
13	11	22	11	21	39	29	31	8	-8	Assimilator
14	7	22	15	19	39	33	29	14	-10	Assimilator
15	4	8	4	26	31	32	31	6	0	Assimilator
16	7	15	8	25	31	32	32	7	1	Assimilator
17	5	8	3	27	30	35	28	8	-2	Assimilator
18	8	19	11	19	44	26	31	7	-13	Assimilator
19	11	22	11	24	30	31	35	7	5	Assimilator
20	7	22	15	21	37	27	35	6	-2	Assimilator
21	9	23	14	20	40	30	30	10	-10	Assimilator
22	9	22	13	21	33	33	33	12	0	Assimilator
23	11	16	5	27	31	31	31	4	0	Assimilator
24	13	14	1	16	36	30	38	14	2	Assimilator
25	7	17	10	20	37	26	37	6	0	Assimilator
26	14	24	10	24	34	37	25	13	-9	Assimilator
27	7	20	13	18	32	36	34	18	2	Assimilator
28	6	16	10	22	33	28	37	6	4	Assimilator
29	12	17	5	22	44	28	26	6	-18	Assimilator
30	11	24	13	19	40	29	32	10	-8	Assimilator
31	6	19	13	30	23	36	31	6	8	Converger
32	10	23	13	22	29	28	41	6	12	Converger
33	12	14	2	19	33	28	40	9	7	Converger
34	4	17	13	22	39	24	35	2	-4	Diverger
35	8	13	5	25	41	24	30	-1	-11	Diverger
36	12	24	12	27	39	26	28	-1	-11	Diverger
37	11	18	7	25	38	20	37	-5	-1	Diverger
38	6	10	4	23	42	24	31	1	-11	Diverger
39	8	16	8	26	38	28	28	2	-10	Diverger
40	8	17	9	23	38	21	38	-2	0	Diverger
41	5	16	11	35	33	20	32	-15	-1	Diverger
42	6	17	11	26	35	21	38	-5	3	Diverger
43	12	22	10	28	40	26	26	-2	-14	Diverger
44	10	15	5	32	36	24	28	-8	-8	Diverger
45	5	13	8	29	29	28	34	-1	5	Diverger

Table 3. Pre and Post Attitude Scores for the Control Group.

Control Group Scores

Control	Pre-Attitudes					Post-Attitudes				
Student	Effectance	Anxiety	Confidence	Usefulness	Success	Effectance	Anxiety	Confidence	Usefulness	Success
1	35	35	43	42	39	35	38	45	50	42
2	47	46	46	51	54	41	43	47	46	48
3	32	18	25	42	55	43	30	30	40	51
4	39	35	44	49	46	29	39	39	30	27
5	31	37	38	40	43	46	41	52	58	60
6	44	34	30	55	58	40	33	40	55	49
7	46	43	46	49	53	31	26	19	23	53
8	37	21	29	46	36	35	27	33	42	38
9	36	43	40	41	49	39	45	36	44	47
10	36	26	33	45	46	48	32	37	48	48
11	47	48	47	50	56	33	47	39	39	41
12	41	45	45	43	48	40	44	48	46	44
13	38	23	35	41	42	46	44	53	49	55
14	48	40	46	59	45	45	37	48	55	48
15	43	27	29	48	60	44	33	41	51	60
16	29	37	40	36	37	31	34	27	21	25
17	31	22	31	47	51	26	24	29	38	38
18	32	38	38	46	49	35	42	38	53	52
19	47	45	48	50	58	45	48	49	48	59
20	40	26	33	56	43	45	40	40	59	35
21	32	26	36	30	45	38	29	33	43	47
22	42	28	37	44	53	36	32	38	46	59
23	35	38	36	33	37	30	35	40	30	33
24	29	23	22	46	51	31	27	30	42	49
25	35	34	38	40	46	41	47	44	39	48
26	37	26	23	48	46	40	41	44	49	51
27	29	31	35	52	52	36	45	42	55	50
28	31	28	28	43	44	33	30	33	48	46
29	37	24	31	52	54	45	44	43	52	56
30	42	36	38	52	53	42	46	49	52	46
31	41	30	32	54	54	33	31	32	55	60
32	40	25	29	59	57	38	34	45	57	60
33	37	24	26	51	41	43	39	44	54	42
34	34	29	30	44	44	29	33	39	46	55
35	45	42	45	43	45	34	42	42	41	43
36	35	33	29	48	45	44	43	35	50	51
37	32	30	35	36	35	34	36	45	30	37
38	36	25	23	40	32	33	33	40	27	41
39	48	33	50	49	39	37	36	43	38	38
40	37	30	29	43	55	36	39	38	47	60
41	39	21	24	44	54	42	29	20	49	55
42	32	31	33	38	42	36	26	30	41	51
43	43	33	38	48	49	34	35	27	41	39
44	35	45	33	50	48	44	32	37	42	43
45	37	27	28	45	49	41	31	32	39	46

Table 4. Achievement and Learning Style Scores for the Treatment Group.

Treatment Group Scores

TreatmentStudent	Achievement			Learning Style						Learning Style
	Pre	Post	Net	Concrete Experience (CE)	Reflective Observation (RO)	Abstract Conceptual-ization (AC)	Active Experiment-ation (AE)	(AC)-(CE)	(AE)-(RO)	
1	10	19	9	28	19	30	43	2	24	Accommodator
2	16	21	5	33	20	29	38	-4	18	Accommodator
3	7	15	8	33	28	24	35	-9	7	Accommodator
4	8	14	6	41	17	25	37	-16	20	Accommodator
5	8	14	6	28	30	23	39	-5	9	Accommodator
6	5	9	4	34	24	31	31	-3	7	Accommodator
7	6	13	7	27	30	25	38	-2	8	Accommodator
8	11	17	6	27	32	22	39	-5	7	Accommodator
9	10	17	7	24	27	25	44	1	17	Accommodator
10	13	16	3	33	28	19	40	-14	12	Accommodator
11	9	23	14	24	31	24	41	0	10	Accommodator
12	7	13	6	32	24	21	43	-11	19	Accommodator
13	9	19	10	26	27	26	41	0	14	Accommodator
14	9	20	11	22	36	33	29	11	-7	Assimilator
15	11	16	5	16	42	27	35	11	-7	Assimilator
16	5	9	4	26	31	31	32	5	1	Assimilator
17	12	16	4	19	39	27	35	8	-4	Assimilator
18	8	24	16	21	38	31	30	10	-8	Assimilator
19	9	18	9	24	33	29	34	5	1	Assimilator
20	10	8	-2	20	43	28	29	8	-14	Assimilator
21	10	17	7	25	31	43	21	18	-10	Assimilator
22	6	14	8	19	42	23	36	4	-6	Assimilator
23	12	15	3	27	30	31	32	4	2	Assimilator
24	3	9	6	19	45	28	28	9	-17	Assimilator
25	17	14	-3	21	30	41	28	20	-2	Assimilator
26	9	20	11	23	25	32	40	9	15	Converger
27	8	15	7	28	23	37	32	9	9	Converger
28	9	12	3	22	31	30	37	8	6	Converger
29	13	16	3	19	29	32	40	13	11	Converger
30	8	15	7	19	32	29	40	10	8	Converger
31	8	15	7	21	43	22	34	1	-9	Diverger
32	10	24	14	37	27	35	21	-2	-6	Diverger
33	11	16	5	28	33	21	38	-7	5	Diverger
34	3	10	7	32	34	24	30	-8	-4	Diverger
35	11	12	1	31	29	30	30	-1	1	Diverger
36	9	24	15	27	33	23	37	-4	4	Diverger
37	6	15	9	22	36	23	39	1	3	Diverger
38	2	10	8	24	40	27	29	3	-11	Diverger
39	7	19	12	26	37	23	34	-3	-3	Diverger
40	9	15	6	28	39	22	31	-6	-8	Diverger
41	6	14	8	28	31	25	36	-3	5	Diverger
42	11	18	7	23	36	23	38	0	2	Diverger
43	11	26	15	27	31	29	33	2	2	Diverger
44	6	15	9	29	37	20	34	-9	-3	Diverger
45	17	22	5	26	34	222	38	196	4	Diverger
46	8	21	13	28	44	16	32	-12	-12	Diverger

Table 5. Pre and Post Attitude Scores for the Treatment Group.

Treatment Group Scores

Treatment	Pre-Attitudes					Post-Attitudes				
Student	Effectance	Anxiety	Confidence	Usefulness	Success	Effectance	Anxiety	Confidence	Usefulness	Success
1	31	21	26	35	59	37	26	41	38	56
2	28	31	32	37	51	28	29	31	34	40
3	31	17	27	43	55	36	27	35	42	52
4	21	26	24	54	53	25	36	31	48	57
5	34	29	35	45	40	30	36	34	37	34
6	35	30	32	39	42	35	31	39	42	38
7	36	17	32	53	41	37	32	30	55	58
8	38	40	43	49	43	37	42	41	38	37
9	39	16	23	41	53	41	46	38	52	46
10	42	47	49	52	46	42	45	50	48	46
11	40	42	47	48	49	41	42	53	55	55
12	33	26	30	46	45	44	41	37	52	60
13	34	25	29	55	60	27	21	28	59	60
14	42	37	45	46	44	37	44	51	56	54
15	41	31	44	60	56	39	33	42	48	57
16	19	35	36	38	48	23	37	28	37	44
17	43	47	47	54	54	41	45	38	46	46
18	44	32	38	46	52	42	32	42	46	43
19	53	16	38	49	53	44	14	39	47	51
20	40	27	32	47	41	32	23	24	44	45
21	40	57	49	38	56	40	47	49	45	53
22	49	19	32	59	45	41	30	39	55	54
23	36	36	34	43	48	30	31	25	48	52
24	31	25	24	38	45	29	27	30	38	44
25	41	40	41	50	45	43	43	41	59	58
26	35	41	38	52	43	31	25	31	46	39
27	33	26	33	48	49	36	35	31	51	60
28	34	28	24	49	46	31	23	32	46	43
29	41	28	33	52	58	44	27	36	56	55
30	30	30	35	60	54	28	24	27	60	43
31	36	25	28	48	53	33	20	25	34	46
32	39	30	34	51	47	44	32	45	47	45
33	32	37	31	51	57	35	35	40	58	60
34	29	28	25	38	40	29	25	22	46	48
35	28	30	33	42	44	32	31	28	31	48
36	41	29	49	50	53	43	45	51	57	50
37	41	45	47	57	47	30	38	42	38	36
38	28	24	18	52	50	26	13	17	47	58
39	24	30	37	43	52	28	35	41	32	42
40	37	23	31	46	39	37	34	36	49	45
41	42	32	35	50	50	31	40	37	42	47
42	36	31	37	43	46	32	30	36	36	44
43	39	41	45	55	54	32	27	29	40	38
44	47	26	21	43	58	39	28	34	56	59
45	43	41	53	55	49	41	44	47	53	52
46	40	27	34	40	43	36	24	32	39	46

APPENDIX F

STATISTICAL ANALYSES

Table 6. Multivariate Tests for Effectance.

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
TIME	.988	1.051[b]	1.000	87.000	.308
TIME * GROUP	.981	1.662[b]	1.000	87.000	.201
TIME * C/A[a]	.998	.174[b]	1.000	87.000	.678
TIME * GROUP * C/A[a]	.988	1.073[b]	1.000	87.000	.303

a. C=Concrete, A=Abstract

b. Exact statistic

Table 7. Between Subjects Tests for Effectance.

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	239972.694	1	239972.694	4417.267	.000
GROUP	135.144	1	135.144	2.488	.118
C/A[a]	45.250	1	45.250	.833	.364
GROUP * C/A[a]	52.856	1	52.856	.973	.327
Error	4726.367	87	54.326		

a. C=Concrete, A=Abstract

Table 8. Multivariate Tests for Anxiety.

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
TIME	.887	11.097[b]	1.000	87.000	.001
TIME * GROUP	.956	4.041[b]	1.000	87.000	.048
TIME * C/A[a]	1.000	.002[b]	1.000	87.000	.961
TIME * GROUP * C/A[a]	.936	5.936[b]	1.000	87.000	.017

a. C=Concrete, A=Abstract

b. Exact statistic

Table 9. Between Subjects Test for Anxiety.

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	191489.565	1	191489.565	1923.520	.000
GROUP	262.177	1	262.177	2.634	.108
C/A[a]	33.763	1	33.763	.339	.562
GROUP *C/A[a]	.201	1	.201	.002	.964
Error	8660.991	87	99.552		

a. C=Concrete, A=Abstract

Table 10. Multivariate Tests for Confidence.

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
TIME	.937	5.897[b]	1.000	87.000	.017
TIME * GROUP	.965	3.124[b]	1.000	87.000	.081
TIME * C/A[a]	1.000	.038[b]	1.000	87.000	.846
TIME * GROUP * C/A[a]	.951	4.463[b]	1.000	87.000	.037

a. C=Concrete, A=Abstract

b. Exact statistic

Table 11. Between Subjects Test for Confidence.

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	229886.830	1	229886.830	2367.721	.000
GROUP	55.794	1	55.794	.575	.450
C/A[a]	86.547	1	86.547	.891	.348
GROUP * C/A[a]	7.277	1	7.277	.075	.785
Error	8447.006	87	97.092		

a. C=Concrete, A=Abstract

Table 12. Multivariate Tests for Usefulness.

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
TIME	.977	2.061[b]	1.000	87.000	.155
TIME * GROUP	.999	.051[b]	1.000	87.000	.823
TIME * C/A[a]	.977	2.034[b]	1.000	87.000	.157
TIME * GROUP * C/A	.999	.082[b]	1.000	87.000	.775

a. C=Concrete, A=Abstract

b. Exact statistic

Table 13. Between Subjects Tests for Usefulness.

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	376425.340	1	376425.340	4586.693	.000
GROUP	193.576	1	193.576	2.359	.128
C/A[a]	425.315	1	425.315	5.182	.025
GROUP * C/A[a]	5.161	1	5.161	.063	.803
Error	7140.004	87	82.069		

a. C=Concrete, A=Abstract

Table 14. Multivariate Tests for Attitude Toward Success.

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
TIME	.999	.069[b]	1.000	87.000	.793
TIME * GROUP	1.000	.004[b]	1.000	87.000	.951
TIME * C/A[a]	1.000	.007[b]	1.000	87.000	.932
TIME * GROUP * C/A[a]	.996	.344[b]	1.000	87.000	.559

a. C=Concrete, A=Abstract

b. Exact statistic

Table 15. Between Subjects Tests for Attitude Toward Success.

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	407597.211	1	407597.211	5168.957	.00C
GROUP	119.414	1	119.414	1.514	.222
C/A[a]	84.261	1	84.261	1.069	.304
GROUP * C/A[a]	20.760	1	20.760	.263	.609
Error	6860.370	87	78.855		

a. C=Concrete, A=Abstract

VITA

Mary Ellen Dickerson Owens was born in Wartrace, Tennessee. She received her high school education from Central High School in Shelbyville, Tennessee. She received her Bachelor of Science degree in Chemistry and Mathematics from Middle Tennessee State University in Murfreesboro, Tennessee (1968), and her Masters of Mathematics degree from the University of Tennessee in Knoxville, Tennessee (1991).

Working experience has included Chemist at Tennessee Eastman Company in Kingsport, Tennessee. This employment involved analytical and organic research in the Research Department. She is currently an Associate Professor of Mathematics at Walters State Community College in Morristown, Tennessee.

Mary is married to Stephen Owens, a Senior Research Chemical Engineer. They have two children, Mary Ellen and Dr. William Todd Owens.