



The effect of mastery learning and wait time on student achievement and attitude in seventh and eighth grade mathematics
by Dale Arthur Olson

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University
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Abstract:

The problem of this study was to determine if mastery learning interacting with the principle of wait time had an effect on students' achievement and attitudes in seventh and eighth grade mathematics classrooms. Analysis of covariance was used to analyze results of posttests with pretests as the covariate. Analysis was done using three tests at each grade level. The Stanford Achievement Test (NRT) and criterion referenced tests (CRT) developed by the researcher were used to measure student achievement. The Aiken-Dreger Mathematics Attitude Instrument (ATT) was used to measure student attitudes.

This study was conducted from September 1987 to January 1988 in nine Montana schools. There were three independent variables which were studied: mastery learning, wait time/ and gender. Teachers who had used mastery learning were trained in the use of wait time along with teachers who had not used mastery learning. Teachers who had not used mastery learning or received training in wait time acted as a control group.

The results for grade 7 were that mastery learning, wait time/ and gender had significant effects on student achievement as measured by the CRT with mastery learning, wait time/ and females having the greater posttest achievement. The posttest NRT results showed females at a statistically greater level. There was a significant three-way interaction on attitude in which females had higher attitude scores in the presence of mastery learning and wait time.

The results for grade 8 showed interactions with the independent variables on the NRT posttest. The interactions had females having the greatest achievement when combined with the treatment" of mastery learning and wait time and males having higher achievement as a control group and with mastery learning and wait time. Mastery learning was a positive and significant main effect for the CRT posttest. Wait time was a negative and significant main effect for the CRT posttest. Mastery learning had a negative main effect on attitude on ATT posttest.

THE EFFECT OF MASTERY LEARNING AND WAIT TIME
ON STUDENT ACHIEVEMENT AND ATTITUDE IN
SEVENTH AND EIGHTH GRADE MATHEMATICS

by

Dale Arthur Olson

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

of

Doctor of Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

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of a thesis submitted by

Dale Arthur Olson

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ABSTRACT

The problem of this study was to determine if mastery learning interacting with the principle of wait time had an effect on students' achievement and attitudes in seventh and eighth grade mathematics classrooms. Analysis of covariance was used to analyze results of posttests with pretests as the covariate. Analysis was done using three tests at each grade level. The Stanford Achievement Test (NRT) and criterion referenced tests (CRT) developed by the researcher were used to measure student achievement. The Aiken-Dreger Mathematics Attitude Instrument (ATT) was used to measure student attitudes.

This study was conducted from September 1987 to January 1988 in nine Montana schools. There were three independent variables which were studied: mastery learning, wait time, and gender. Teachers who had used mastery learning were trained in the use of wait time along with teachers who had not used mastery learning. Teachers who had not used mastery learning or received training in wait time acted as a control group.

The results for grade 7 were that mastery learning, wait time, and gender had significant effects on student achievement as measured by the CRT with mastery learning, wait time, and females having the greater posttest achievement. The posttest NRT results showed females at a statistically greater level. There was a significant three-way interaction on attitude in which females had higher attitude scores in the presence of mastery learning and wait time.

The results for grade 8 showed interactions with the independent variables on the NRT posttest. The interactions had females having the greatest achievement when combined with the treatment of mastery learning and wait time and males having higher achievement as a control group and with mastery learning and wait time. Mastery learning was a positive and significant main effect for the CRT posttest. Wait time was a negative and significant main effect for the CRT posttest. Mastery learning had a negative main effect on attitude on ATT posttest.

CHAPTER 1

INTRODUCTION

Introduction

Educators have long sought effective methods of instruction. Anderson (1983) and Bloom (1984) suggested that optimal combinations of teaching methods exist. In analyzing effective methods of instruction by meta-analysis (Block & Burns, 1976; Wise & Okey, 1983; Willet, Yamashita, & Anderson 1983; Bloom, 1984; Guskey & Gates, 1986; Rowe, 1986), two methods have been identified that have positive effects on students' affective and cognitive domains. The two methods are mastery learning and wait time. Although these two methods have been shown to be effective independently, there is no research on their effectiveness when used together.

Mastery learning is an instructional program model which has contributed much to the knowledge of how individuals learn. Carroll (1963), in the original theoretical work on mastery learning, stated that learning was a function of the ratio of the time spent learning to the time needed for learning. Carroll further stated that the time spent is influenced by the learner's perseverance

and opportunity to learn and the time needed is influenced by aptitude, the quality of instruction, and the ability to understand the instruction.

Bloom (1968) transformed Carroll's theoretical work into a working instructional program model for schools. The basic features of Bloom's instructional program model are:

- 1) The learner must understand the nature of the task he is to learn and the procedure he is to follow in learning it.
- 2) Formulation of specific instructional objectives for the learning task is important. . . .
- 3) It is useful to break a course or subject into small units of learning and to test at the end of each unit.
- 4) The teacher should provide feedback on the learner's particular errors and difficulties after each test.
- 5) The teacher must find ways to alter the time some individuals need to learn.
- 6) It may be profitable to provide alternative learning opportunities.
- 7) Student effort is increased when small groups of two or three students meet regularly for as long as an hour to review their test results and to help one another overcome the difficulties identified by means of the test (McNeil, 1969, p. 38).

Block and Anderson (1975) further refined Bloom's model for application in the classroom by providing direction as to the construction of mastery learning units and the component parts of a mastery learning unit. They suggested components should contain clear objectives, formative and summative tests, correctives, enrichments, and tables of specification. They also suggested that the

method of mastery learning be clearly communicated to students.

Guskey (1985), as a result of his research, developed a three-stage strategy for implementation of mastery learning in schools. These three steps are: 1) planning, 2) managing, and 3) evaluating mastery learning. Planning involves defining what is to be learned and the level of mastery to be achieved along with development of formative and summative tests, corrective activities, and enrichment activities which blend in with managing mastery learning. The basic suggested flow of management of mastery learning includes instruction, diagnostic (formative) testing, correctives or enrichment based on the results of the formative testing, and diagnostic testing for those who did not achieve mastery after initial instruction. Evaluation involves summative testing over several units to come to a conclusion about instruction and how instruction should be modified.

The success of mastery learning has been demonstrated by numerous studies summarized by meta-analyses (Block & Burns, 1976; Willet et al., 1983; Walberg, 1984; Guskey & Gates, 1986). Block and Burns (1976) found 59 of 97 studies reviewed to be statistically significant ($p < .05$) for the mastery learning group over the control group, nonmastery, in regard to cognitive achievement. Another 27

of the 97 studies showed mastery learning to have higher cognitive achievement than the nonmastery group but the results were not statistically significant. Block and Burns also found that 14 out of 17 studies demonstrated mastery learning had positive effects on the affective domain; eight of the 14 were statistically significant ($p < .05$). They also found in the three remaining studies the nonmastery groups had higher affect scores than the mastery group but the scores were not statistically significant.

Willet et al. (1983) studied systems of instruction which included mastery learning, Personalized Systems of Instruction (PSI), contracts for learning, computer based instruction, media based instruction, team teaching, programmed learning, departmentalized instruction, and individual instruction. A total of 341 effect sizes were computed, with a mean effect of .10 and standard deviation of .41. Effect sizes were computed using the approach of Glass, McGaw, & Smith (1981) in which a value, called the effect size, is computed by dividing the difference of the mean of the experiment group and the mean of the control group by the standard deviation of the control group. The systems which demonstrated the largest effects for the cognitive domain were mastery and PSI, .64 and .49, respectively. Both mastery and PSI demonstrated the

largest average effect in the affective domain with an effect size equal to .52 for both mastery and PSI. Walberg (1984) and Guskey and Gates (1986) experienced similar results in the meta-analysis that they conducted.

The phenomenon and concept of wait time was first observed and explained by Rowe and Hurd in 1966. Wait time and mastery learning are connected by the common variable of time, in that mastery learning allows the time for a student to assess failure and to correct the failure and wait time allows the preservation of the right to fail and to correct the failure. Rowe (1974c, p. 209) stated:

Exploration and inquiry require students to put together ideas in new ways, to try out new thoughts, to take risks. It is in preserving for them the right to be wrong that they gain courage to try out new ideas, to explore more alternatives, to objectively evaluate their own work as well as that of others. For that, they not only need time but they also need a sense of being safe.

Rowe (1974a) defined the concepts of wait time. Wait time one (1) is the amount of time a teacher waits after asking a question of students and wait time two (2) is the amount of time a teacher waits after a student responds to a question. Rowe stated that a teacher typically waits one second or less for both wait times but significant gains in student understanding can be made if teachers increase both wait times to 2.7 seconds or more.

Rowe (1974c) characterized the classroom as a two player game in which one player is the instructor and the other player is represented by all the students in the class. The moves available to the players are: structuring, soliciting, responding, and reacting or evaluating. Rowe observed that responding, typically, was the students' only move, whereas the instructor dominated the three remaining moves. Further analysis of classroom dialogue, in which the students' primary move was responding with the instructor dominating the soliciting, reacting, and evaluating moves, revealed that the pattern of classroom dialogue was not dependent on any of the following: size of class, lack of material for instruction, knowledge of the material, type of curricula, age of students, or geographic region. In the same study Rowe trained 74 teachers in wait time and observed the change in the types of questions asked by teachers. Before instruction the ratio was 3:82:13:2 for ratio of rhetorical:informational:leading:probing questions; after instruction the ratio was 2:34:36:28. These results indicated that wait time and complex cognitive processes may be related.

Rowe (1974b) studied the relationship of wait time and verbal rewards in classrooms. Rowe's research indicted that the effects of longer wait time were smaller when

overt verbal rewards were used frequently. Observational conclusions of groups revealed that overt verbal rewarding can have a negative effect on task persistence. Rowe also observed different patterns of verbal rewarding for high ability students in comparison to low ability students, with low ability students receiving ambiguous patterns of verbal rewards. When teachers used overt verbal rewards instruction was centered more on the teacher's behavior in relation to the task than the task itself.

Rowe proposed that studies of wait time should consider teacher's verbal reward patterns as a confounding variable. Rowe stated that longer wait times with low rewards would change the dynamics in a classroom such that the moves of structuring, evaluating, and soliciting would shift from the teacher to students or groups of students working together.

Rowe (1976, 1980) offered a model for the use of wait time in a modified form for classrooms which follow a lecture format. This model involved instructors pausing for two minutes for every eight minutes of lecture. Rowe hypothesized that this would be effective because of lapses that occur in the course of a lecture which are due to

- 1) content shifts which are not apparent to the learner,
- 2) new ideas which are not immediately grasped,

3) independent divergent thoughts away from the flow of lecture, and 4) contextually dense material which is not easily grasped. During these two-minute pauses students would form into groups of three in which misconceptions and ideas presented in the lecture would be cleared up and discussed. Rowe believed that the use of such a technique would reinforce new ideas and clear up misconceptions that occur during the course of a lecture.

Rowe (1986, pp. 44-45) summarized the effects of the longer wait times on students:

- 1) The length of student responses increases between 300% and 700%, in some cases more, depending on the study.
- 2) More inferences are supported by evidence and logical argument.
- 3) The incidence of speculative thinking increases.
- 4) The number of questions asked by students increases, and the number of experiments they propose increases.
- 5) Student-student exchanges increase; teacher-centered 'show and tell' behavior decreases.
- 6) Failures to respond decrease.
- 7) Disciplinary moves decrease.
- 8) The variety of students participating voluntarily in discussions increases. Also, the number of unsolicited, but appropriate, contributions by students increases.
- 9) Student confidence, as reflected in fewer inflected responses, increases.
- 10) Achievement improves on written measures where the items are cognitively complex.

The effects on teachers (Rowe, 1986, p. 46) were:

1. Teachers' responses exhibit greater flexibility. This is indicated by the occurrence of fewer discourse errors and

- greater continuity in the development of ideas.
2. The number and kind of questions asked by teachers changes.
 3. Expectations for the performance of certain students seems to improve.

Problem Statement

It is a goal of educators to maximize student achievement and positive changes in attitude. Therefore, the problem of this study was to determine if mastery learning interacting with the application of wait time had an effect on students' achievement and attitudes in seventh and eighth grade mathematics classrooms.

Need for the Study

Several researchers (Mevarech, 1980; Burke, 1983; Leyton, 1983; Luiten, Ames, & Ackerson, 1980; Levin, 1979) have sought methods to make large group instruction as effective as tutoring. To make large group instruction as effective as tutoring, Bloom (1984) suggested that mastery learning be combined with one or all of the following: entry level skill remediation, advanced organizers, parental support, participation by students, or better classroom materials. Bloom (1984) stated the fact that 95 percent of the questions asked in American schools are at the lower three levels of his taxonomy. Rowe (1986) believed the use of wait time would bring about improved

achievement on cognitively complex questions and tasks by increasing the number of higher level questions. Wise and Okey (1983, p. 435), in a meta-analysis of science teaching strategies, wrote, "It is interesting to imagine how several strategies, none of which has an overwhelming impact, might influence achievement if used in concert." Anderson (1983, p. 504), stated "There seems to be reason for researchers and practitioners to consider the optimal application of combinations of treatments." Rugheimer (1987) hypothesized the idea of a synergistic effect in relationship to instructional strategies.

In the National Council of Teachers of Mathematics (NCTM) Agenda for Action (1980), problem solving was identified as the primary thrust for the 1980's mathematics curriculum. "The higher order mental processes, logical reasoning, information processing, and decision making should be considered basic to the operation of mathematics" (p. 8). Carpenter, Corbitt, Kepner, Linguist, and Reys (1981), in their evaluation of the National Assessment of Educational Progress (NAEP) data, stated that mathematics education is a long way from reaching its goal of teaching students to be problem solvers. The evaluation of the NAEP data also indicated that students' perceived role in mathematics was primarily a passive role. Carpenter et al. (1981, p. 36) stated:

They (students) are to sit and listen and watch the teacher do problems; the rest of the time is to be spent working on an individual basis on problems from the text or worksheets. They feel they have little opportunity to interact with their classmates about the mathematics being studied, to work on exploratory activities, or to work with manipulatives. An attempt to evaluate the implications of these results (NAEP) for the curriculum of the 1980s leads directly to the issue of student involvement in the learning process. The results suggest that the current situation, at least from the students' point of view, is one in which mathematics instruction is 'show and tell' on the teacher's part, 'listen and do' for the students. Students' perception of their involvement is in direct contrast to the recommendations of NCTM. If active student involvement in mathematics learning is as desirable and sought after as the NCTM recommendations imply, then changes in approaches to teaching mathematics that will foster and encourage that involvement must be implemented.

An online review of the ERIC index conducted on February 17, 1987, revealed that there were only two articles in the index which combined wait time with mastery learning. Both articles contained lists of effective instructional strategies but neither was research based. An online search of Dissertation Abstracts International conducted February 25, 1987, revealed that no work had been done to investigate the relationship of wait time in conjunction with mastery learning.

Anderson (1983) concluded as a result of meta-analyses that mastery learning and Personalized System of Instruction (PSI) had the largest effect size in regard to

instructional programs. Wise and Okey (1983) suggested in the same series of meta-analyses that wait time, questioning techniques, and manipulatives have the largest effect size in regard to instructional strategies and techniques.

Since the meta-analyses suggested that mastery learning and wait time independently have large effect sizes and no research had been done looking at both effects in concert, there was a need for this study. This study added to the knowledge of two effective methods of instruction used together.

General Questions to Be Answered

This study was designed to answer the following questions:

1) Did the mathematics achievement, as measured by Norm Referenced Tests (NRTs), of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, wait time and no wait time, and the attribute variable of gender?

2) Did the mathematics achievement, as measured by NRTs, of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, and wait time and no wait time?

3) Did the mathematics achievement, as measured by NRTs, of seventh and eighth grade students interact with the treatments of wait time and no wait time, and the attribute variable of gender?

4) Did the mathematics achievement, as measured by NRTs, of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, and the attribute variable of gender?

5) Was the mathematics achievement, as measured by NRTs, of seventh and eighth grade students different for wait time versus no wait time?

6) Was the mathematics achievement, as measured by NRTs, of seventh and eighth grade students different for mastery learning versus no mastery learning?

7) Was the mathematics achievement, as measured by NRTs, of seventh and eighth grade students different for the attribute variable of gender?

8) Did the mathematics achievement, as measured by Criterion Referenced Tests (CRTs), of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, wait time and no wait time, and the attribute variable of gender?

9) Did the mathematics achievement, as measured by CRTs, of seventh and eighth grade students interact with

the treatments of mastery learning and no mastery learning, and wait time and no wait time?

10) Did the mathematics achievement, as measured by CRTs, of seventh and eighth grade students interact with the treatments of wait time and no wait time, and the attribute variable of gender?

11) Did the mathematics achievement, as measured by CRTs, of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, and the attribute variable of gender?

12) Was the mathematics achievement, as measured by CRTs, of seventh and eighth grade students different for wait time versus no wait time?

13) Was the mathematics achievement, as measured by CRTs, of seventh and eighth grade students different for mastery learning versus no mastery learning?

14) Was the mathematics achievement, as measured by CRTs, of seventh and eighth grade students different for the attribute variable of gender?

15) Did the mathematics attitude, as measured by the Aiken-Dreger Mathematics Attitude Instrument (ATT), of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, wait time and no wait time, and the attribute variable of gender?

16) Did the mathematics attitude, as measured by ATT, of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, and wait time and no wait time?

17) Did the mathematics attitude, as measured by ATT, of seventh and eighth grade students interact with the treatments of wait time and no wait time, and the attribute variable of gender?

18) Did the mathematics attitude, as measured by ATT, of seventh and eighth grade students interact with the treatments of mastery learning and no mastery learning, and the attribute variable of gender?

19) Was the mathematics attitude, as measured by ATT, of seventh and eighth grade students different for wait time versus no wait time?

20) Was the mathematics attitude, as measured by ATT, of seventh and eighth grade students different for mastery learning versus no mastery learning?

21) Was the mathematics attitude, as measured by ATT, of seventh and eighth grade students different for the attribute variable of gender?

General Procedures

This study was conducted in seventh and eighth grades in school districts in Montana. Permission was obtained

from the superintendent or the Board of Education, in accordance with board policy.

The researcher asked teachers to participate in the study and conferred, monitored, and assisted all participants in the study every three weeks while the study was in progress. Instructors were trained in the use of wait time in an inservice session conducted by the researcher.

Teachers taught two sections of mathematics at the same grade level. These two sections were in one of the following categories: control (no wait time, no mastery learning), mastery learning, wait time, and mastery learning with wait time. If an instructor had more than two sections of a given grade level, two sections were chosen at random. Assignment of students to groups was done on a random basis as permitted by student schedules. Assignment of methods to groups was random. Confidentiality of instructors and students was achieved by a coded key known only to the researcher. The teachers participating were informed on a timely basis as to the results of the study.

The Aiken-Dreger Mathematics Attitude Instrument (ATT), which was used to measure students' attitudes, and the Stanford Achievement Test (NRT) and criterion referenced tests (CRT), which were used to measure

students' achievement, were administered by the instructors involved in this study. All students involved were pretested and posttested using the ATT, NRT, and CRT before and after treatment. The CRTs were developed by the researcher.

Hypotheses related to the questions were formed. The data obtained were analyzed by using three factor ANOVAs and ANOCOVAs to answer the hypotheses stated for the posttest results.

Limitations and Delimitations

The limitations of the study were the following:

1. This study was limited to the students enrolled in seventh and eighth grade mathematics at the sites of this study from August of 1987 to January of 1988.

2. This study was limited by the use of teachers who volunteered to participate.

This study was delimited to examining the value of mastery learning, wait time, the interaction effect of achievement and attitude in relation to the treatments and gender.

Definition of Terms

Mastery learning was defined as an instructional program in which a topic is defined in terms of specific learner objectives. It included formative testing to

assess and make decisions in regard to instruction for both the group and individuals, corrective measures and enrichment activities as a result of the formative testing procedure, and summative testing done to evaluate instruction (Guskey, 1985).

Wait time was defined as the time an instructor pauses after asking a question, wait time 1, and the time an instructor pauses after students respond to a question, wait time 2 (Rowe, 1986). Wait time, in this study, also included the pausing principle which was defined as the practice of taking two minute breaks every eight minutes in the course of a lecture. During this two minute break, students discussed ideas or problems that arose during the last eight minutes of the lecture.

Synergistic effect was defined as when the total effect of two or more treatments is greater than the sum effect of these individual treatments (Rugheimer, 1987).

Effect size was defined as the difference between the quantity, the experimental mean and the control mean, divided by the standard deviation of the control (Glass et al., 1981).

Student achievement was defined as the raw scores from a pretest and posttest situation as measured by the subtest of mathematics application on the Stanford Achievement Test (NRT).

Student attitude was defined as the score achieved on the Aiken-Dreger Mathematics Attitude Scale test battery.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

For the purpose of this study the literature was reviewed and organized along the major topics of mastery learning, its historical and theoretical development, and wait time research. Peer tutoring as related to wait time, attitudes in mathematics, and the attribute variable of gender will also be discussed.

Mastery Learning

Mastery learning is driven by a belief system that all children can achieve and achieve at a high level (Block & Burns, 1976). Carroll (1963) developed one of the first models of mastery learning which included the idea of achievement at high levels for the majority of students.

The basic factors, according to Carroll (1963), which determine the degree of learning, are the time spent by a student to reach a high level of achievement and the time needed by the student to reach a high level of achievement. Carroll stated that the degree of learning was a function of the ratio of time spent to the time needed by the

student. Carroll described the time spent on learning in terms of the opportunity to learn, which is the time allowed for learning, and perseverance to learn. The time needed was determined by three factors: 1) aptitude, 2) quality of instruction, and 3) ability to understand instruction. Carroll described aptitude in a simple sense. A person with high aptitude in a particular subject would take a small amount of time to learn a particular task; students with low aptitude would take a longer amount of time to learn the same task. Carroll characterized quality instruction as including clear objectives and the means to reach those objectives and adaptations by the instructors to meet the special needs and characteristics of the learner. Carroll also included textbooks and other materials as elements that affect the quality of instruction. The ability to understand instruction is controlled by the quality of instruction, aptitude of the student, and a combination of general intelligence and verbal ability. Carroll stated that poor quality instruction can adversely affect a student's ability to understand instruction.

Bloom (1968) devised a model for the use of Carroll's ideas in the classroom. Bloom credited the learning for mastery strategy as coming from the works of Morrison (1926), Skinner (1954), Goodlad and Anderson (1959),

Carroll (1963), Brunner (1966), Suppes (1966), and Glasser (1968). A major motivation for Bloom was to decrease the frustration as a result of the lack of success experienced by students based upon their experience in school. Bloom (1968, p. 2) stated:

Increasingly, learning throughout life (continuing learning) will be necessary for the largest proportion of the work force. If school learning is regarded as frustrating and even impossible by a sizable proportion of students, then little can be done at later levels to kindle a genuine interest in further learning. School learning must be successful and rewarding as one basis for insuring that learning can continue throughout one's life as needed.

As a solution to this problem, Bloom (1968) proposed to make the time allotted for instruction a variable and to direct teachers to the variables which teachers control. Those variables are the opportunity to learn and the quality of instruction.

Bloom's model involved the following: 1) defined learner tasks or outcomes, 2) feedback to the students as to their progress on their tasks on a regular basis, 3) feedback allowing the learner to see where they and the teacher are having difficulty, 4) instructional changes so as to allow another opportunity to learn the given content, 5) increasing student opportunity by using peer-tutoring in groups of two or three in order to increase achievement by concentrating on the difficulties that exist (McNeil, 1969).

In the first meta-analysis of mastery learning conducted in 1976 by Block and Burns, it was apparent that mastery learning improved student achievement. Mastery learning, according to Block and Burns, resulted in an effect size of .83. Guskey and Gates (1986), in a meta-analysis of mastery learning from 1976 to 1986, showed effect sizes for science education, mathematics, social studies, and language arts of .78, .81, .91, and .99, respectively.

Rollins (1983) in a study involving the implementation of mastery learning into a seventh and eighth grade junior high school in the subject areas of mathematics, science, and social studies, found significant gains in achievement for all groups using mastery learning except eighth grade mathematics. The eighth grade mathematics mastery learning group and the nonmastery learning group showed no significant difference in achievement.

Bloom (1984) stated that the possibilities exist of making group instruction as effective as tutoring. Walberg (1984) identified that tutorial instruction had an effect size of 2.00 when compared to typical classroom instruction. Bloom suggested that mastery learning in combination with other strategies was the most effective approach available to make group instruction as effective as tutoring. The strategies proposed by Bloom (1984) which

would make large group instruction as effective as tutoring all included mastery learning in combination with one or more of the following: 1) remediation of entry level skills, 2) the use of advanced organizers, 3) involvement of parents, 4) the use of better materials, 5) questioning strategies, and 6) active student participation in the classroom. Several researchers (Mevarech, 1980; Burke, 1983; Leyton, 1983; Levin, 1979; Nordin, 1979; Tenenbaum, 1982) have sought methods to make large group instruction as effective as tutoring by combining mastery learning with other instructional strategies.

Leyton (1983) studied the effects of remediating initial cognitive entry prerequisites in Algebra II and French II. Leyton found that remediating prerequisites caused an effect size of approximately 0.7. When Leyton combined mastery learning with remediation of initial cognitive entry prerequisites, the effect size was approximately 1.6.

Tenenbaum (1982) studied the effects of reinforcement cues and participation. He found that by combining mastery learning with enhanced cues, participation, and reinforcement, the effect size was approximately 1.7 when compared to the control group.

Slavin (1987) disagreed with Bloom's (1984) conclusions. Slavin used a "best-evidence synthesis"

technique to review the literature on mastery learning. A "best-evidence synthesis" combines meta-analysis with the traditional narrative review. Upon using this approach, Slavin concluded that student performance on NRT measures is unchanged by the use of mastery learning. Slavin stated that gains on CRT measures, while moderate when mastery learning is used, showed little evidence that these gains are maintained over time. Slavin stated that mastery learning by itself does not produce significant gains in student achievement, but the gains seen are due to increased instructional time.

Anderson (1983, p. 504) concurred with the concept that an optimal approach exists by stating, "There seems to be reason for researchers and practitioners to consider the optimal application of combinations of treatments."

The large scale meta-analysis conducted by Anderson (1983) suggested that mastery learning and Personalized Systems of Instruction (PSI) are the most effective methods for instruction in science when considering effect sizes. In the same large scale meta-analysis study, wait time, questioning strategies, focusing, and use of manipulatives were identified as the most effective strategies for teaching science when considering effect sizes.

Wait Time

At the same time the mastery learning paradigm was being developed, an instructional strategy called wait time was being investigated. This work in wait time was initially done in response to the lack of success by many of the science curriculums of the 1960s. Rowe (1986) gave the philosophical basis for wait time in stating:

To grow, a complex thought system requires a great deal of shared experience and conversation. It is in talking about what we have done and observed, and in arguing about what we make of our experiences, that ideas multiply, become refined, and finally produce new questions and further explorations (p. 43).

Rowe (1969) studied hundreds of audio tapes of elementary science teachers using new science curricula. This analysis was conducted because of the overall lack of success with the new curricula when compared with the traditional science curricula. A small number of elementary teachers who were having great success with the new curricula were identified as having different speech patterns from those elementary teachers who were not having success. This difference in speech patterns was identified as the amount of time an instructor waited after asking a question.

Upon further analysis, Rowe (1969) concluded that the pace of interaction between students and an instructor was very rapid. Rowe's analysis revealed that the time between

the end of an instructor's question and the beginning of a student's response (wait time 1) was less than one second for most instructors. A second concept, which involved the time from the end of a student's answer to the beginning of the instructor's response (wait time 2), was also less than one second (Rowe, 1974a).

Rowe (1974b) investigated the interrelationship between wait time and overt verbal teacher rewards. Upon analysis, Rowe discovered that overt verbal rewarding patterns decreased student task persistence. High verbal reinforcement schedules discouraged sharing of ideas since someone may be praised for another's ideas. These observations of verbal rewarding patterns presented a confounding variable when wait time was used. Rowe concluded that overt verbal rewards should be administered sparingly if one is interested in developing inquiry behavior in students.

Rowe (1974c) discovered that wait times of less than three seconds had no effect on students' interaction with the instructor. Rowe built a model in which the classroom is characterized as a two player game. One player was the teacher and the other player was the collective students in the class. The moves available to the players were structuring, soliciting, responding, and evaluating. In all but a few classes in which Rowe observed, students were

limited to responding. The teacher dominated the remaining moves. These results were found to be independent of group size, materials, experience and education of the teacher, age of students, and geographical region. Upon training teachers in the use of wait time, Rowe observed marked changes in the moves of the teacher and the students. These changes were: 1) the length of student responses increased, 2) the number of unsolicited but appropriate responses increased, 3) the failure of students to respond decreased, 4) confidence as reflected by fewer inflected responses increased, 5) speculative thinking by the students increased, 6) the number of student questions increased, 7) lower ability students contributed more, and 8) the variety of students' questions increased.

Rowe (1976) suggested that a variation of wait time, called the "pausing principle" be used in lecture format classes. The pausing principle involved taking breaks during a lecture in which students discussed the material presented for two minutes. These breaks occurred every eight to ten minutes. The rationale was that mental lapses occur in all students, lapses occur more often with more complex material, and lapses occur at different times for different students. The pausing principle would fill the lapses that had occurred for students. This variation

would allow students in a lecture to ask questions, which is not a normal part of the lecture format.

Rowe (1980) suggested that students work in groups of three, triads, when using the pausing principle and that this can result in the reinforcement of new ideas, increased student learning, and a decrease in misconceptions.

The application of the pausing principle as a variation of wait time involves students teaching students, which has been characterized as peer tutoring. Grossman (1985) concluded that peer tutoring in combination with mastery learning generated marked improvement in students' academic achievement, attitude, and attendance. Grossman suggested that designing student tutoring groups should take the academic and social needs of the students into account.

In designing peer tutoring groups, triads, Gartner, Kohler, & Riessman (1971) suggested that when the primary emphasis of the peer tutoring is upon the material being taught, the members of the tutoring group can change. Classroom management must be a key element in the arrangement of groups. Students who have been discipline problems or have frequently been off-task should not be placed in the same group (Stahlbrand, 1984). A general mix of academic abilities should be sought in the groups.

According to Cloward (1976, p. 288), "There is virtually no correlation between a tutor's intellectual credentials and his effectiveness of tutoring." Peer tutoring groups should be formed with consideration of personality factors such that the group can function and the potential for growth is present for all the members of the triad (Cloward, 1976).

The process of teaching instructors in the use of wait time is difficult. Swift and Gooding (1983) discovered that even using a variety of techniques such as inservice, manuals, electronic devices, and combinations of these resulted in initial use of wait times, but when these techniques were removed, the instructors returned to their original speech patterns.

Gooding, Swift, and Swift (1987) trained teachers in the use of wait time by use of an electronic device combined with positive feedback on audio tapes of classroom discussions. The results of this study showed that positive feedback with an electronic device gave:

- (1) greater wait time 1,
- (2) greater wait time 2,
- (3) greater percentage of talk by students,
- (4) greater percentage of higher level questions,
- (5) greater length in student responses, and
- (6) higher Piagetian operational levels.

Tobin and Capie (1982) studied the use of wait time in middle school science classrooms. The areas of questioning, wait time, locus of control, pupil engagement, formal reasoning ability of students, and student achievement were investigated. The conclusions of this study were that teachers' behaviors involving questioning and wait time affected all of the student variables studied. Tobin and Capie (1982) concluded that wait time can be used to improve student achievement. The questions asked by teachers should be relevant, clear, and focused at a variety of levels for optimal student engagement. Tobin and Capie also concluded that a three second wait time was necessary to have an effect.

Rowe (1986, pp. 44-45) summarized the results of numerous studies on wait time which involved using wait times of three seconds or more as having the following results:

- 1) The length of student responses increases between 300% and 700%, in some cases more, depending on the study.
- 2) More inferences are supported by evidence and logical argument.
- 3) The incidence of speculative thinking increases.
- 4) The number of questions asked by students increases, and the number of experiments they propose increases.
- 5) Student-student exchanges increase; teacher-centered 'show and tell' behavior decreases.
- 6) Failures to respond decrease.
- 7) Disciplinary moves decrease.

- 8) The variety of students participating voluntarily in discussions increases. Also, the number of unsolicited, but appropriate, contributions by students increases.
- 9) Student confidence, as reflected in fewer inflected responses, increases.
- 10) Achievement improves on written measures where the items are cognitively complex.

Rowe (1986) concluded that the practice of wait time was cross-cultural as a result of studies performed in South America and Thailand which gave similar results to her original work.

Tobin (1986) studied the effects of wait time in mathematics and language arts courses. Tobin showed that training teachers in the use of wait time resulted in the following: (1) students were more often able to respond to questions, (2) the length of students' responses increased, and (3) students were more likely to respond to one another.

Joyce and Showers (1988) suggested that wait time and Teacher Expectation and Student Achievement (TESA) are specific teaching practices which are applicable across teaching models, teaching styles, and grade levels. Joyce and Showers (1988, p. 44) wrote:

Again, they (wait time and TESA) have provided a very direct avenue to helping teachers produce what most observers would agree is a more desirable classroom climate, an avenue that can be followed with modest amounts of training and that promises general educational benefits in the personal, social, and academic domains.

Attitude in Mathematics

A student's attitude toward mathematics is important because of the impact attitude has on the cognitive processes. Tsai and Walberg (1983), in an analysis of the 1977-1978 National Assessment of Educational Progress (NAEP) data, concluded that achievement was significantly associated with attitudes, gender, ethnicity, the education of the mother and the father, verbal opportunities at home, and frequency of mathematical practices. Attitudes were not significantly effected by gender or ethnicity.

Tsai and Walberg (p. 272) stated:

Mathematics attitude is also influenced by home conditions and achievement. Causality, however, may be reciprocal: the more one learns, the higher the attitude; and the higher the attitude, the greater one learns. Improving attitude and encouraging greater learning are both important for long-term results.

Charles and Lester (1984) reported that instruction in problem solving techniques also produced positive changes in teacher and student attitudes, which is concurrent with Tsai and Walberg (1983). Minato and Yanase (1984, p. 319) studied the relationship between intelligence and attitude and concluded that "the attitude of low intelligence students is more important and it affects more in magnitude than that of high intelligence students."

McLeod (1986) suggested that the affective factors on cognitive processes have yet to be studied in detail.

McLeod (p. 23) concluded:

Current efforts to improve problem solving are a major goal of mathematics education. For all students to achieve this goal, researchers and developers need to find better ways to address affective influences on problem solving. By integrating these new ideas on affect into current research and development efforts, we should be able to improve mathematical problem solving for all students, especially women and minorities.

Given the nature of the range of emotions present in a mathematics classroom, the affective domain is a necessary category of investigation (Kulm, 1980).

Gender

Gender has been an issue in mathematics education for some time. Tobias (1978) suggested that the loss of interest in mathematics by girls at puberty is a result of sex bias. There are also indications, as a result of Scholastic Aptitude Test scores, that gender results in different levels of achievement (Educational Research Service, 1981).

The conclusion that men achieve higher scores than women at the high school level is supported by the research of Armstrong (1981) and Pallas and Alexander (1983). Each of these studies noted that both genders start with equal

mathematical ability at the beginning of the high school programs.

The attempt to identify the cause of the differentiated achievement by gender has not shown a clear solution. Fennema and Sherman (1977) suggested the difference in achievement is due to differential socialization processes. Pallas and Alexander (1983) concluded that the difference in achievement is due in part to the pattern of coursework taken in mathematics by men and women. Benbow and Stanley (1980) and Geschwind (1982) concluded that the differences exist due to superior male mathematical ability.

Ethington and Wolfle (1986) suggested a model which accounts for the differential in mathematics achievement by the genders. The model included the variables of mathematics ability, verbal ability, mathematics attitudes, mathematics exposure, and mathematics achievement. This study included 7,643 men and 8,912 women from the High School and Beyond (HSB) survey. These five variables showed that:

Mathematics ability and exposure to mathematics were the most influential causes of mathematics achievement. With regard to the causes of mathematics exposure and attitudes, it had been hypothesized that the effects from both mathematics and verbal ability would be positive. In the event, we found that verbal ability had a negative effect on attitudes toward mathematics for both men and women. Higher verbal ability apparently leads to less favorable attitudes

toward mathematics net of the influence of mathematics ability (p. 70).

In addressing the gender achievement issue, Ethington and Wolfle (1986, p. 72) stated that the differences between men and women were in four areas. These were:

. . . the effects of verbal ability on exposure to mathematics, of verbal ability on attitudes toward mathematics, of attitudes toward mathematics on mathematics achievement, and of sophomore mathematics ability on senior mathematics achievement. The influences of verbal ability in this model are particularly interesting due to the strong positive effects of verbal ability on mathematics achievement for both sexes, despite sex differences in both the influence of verbal ability on mathematics attitudes and the influence of mathematics attitudes on mathematics achievement. Higher verbal ability leads to more negative attitudes toward mathematics for women than for men, yet attitudes in turn have a stronger positive influence on mathematics achievement for men. Verbal ability also has a greater positive effect on exposure to mathematics for men.

Fennema and Tartre (1985, p. 205) concluded their study of gender differences by stating:

One must never say, think, or, most of all, believe that all girls are less able than boys. . . . too many people believe that large differences between the sexes exist where they do not.

Mastery learning, wait time, and gender have all demonstrated effects on students' achievement and attitudes in mathematics. The effects of the combination of mastery learning, wait time, and gender posed the questions this research attempted to answer.

CHAPTER 3

PROCEDURES

Introduction

The problem of this study was to determine if mastery learning interacting with the application of wait time had an effect on students' achievement and attitude in seventh and eighth grade mathematics classrooms. Gender and treatment interactions were also examined in this study. The procedures that were used to collect, organize, and analyze data are discussed and described in this chapter. The topics and procedures are presented as follows:

- 1) Population description and sampling procedures,
- 2) Definition of treatments,
- 3) Methods of data collection,
- 4) Organization of data,
- 5) Statistical hypotheses,
- 6) Analysis of data, and
- 7) Precautions taken for accuracy.

Population Description and
Sampling Procedures

The population consisted of students and teachers in grades 7 and 8 in Roundup, Cut Bank, Lewistown, Livingston, Hardin, Billings, Bozeman, Fort Benton, and Baker, Montana. Roundup, Cut Bank, Lewistown, Livingston, Hardin, Fort Benton, and Baker are all ranching and farming communities. Roundup, Cut Bank, Hardin, and Baker are impacted to a varying extent by oil or coal development. Bozeman is a university community.

Roundup is a community of 2,100 residents located in the Bull Mountains 50 miles north of Billings, the largest city in Montana. Roundup has an economy based on agriculture, oil production, and forestry products. The total enrollment in Roundup's seventh and eighth grades is 111 (Office of Public Instruction, 1986). The secondary school employs a total of 22 teachers, three of whom are responsible for mathematics instruction for grades 7-12. One instructor with 11 years of teaching experience, who teaches seventh and eighth grade mathematics and has participated in at least one year of inservice in mastery learning, agreed to participate in this study.

Cut Bank is a community of 3,700 residents located in north central Montana 30 miles from the Canadian border. Cut Bank's economy is based on agriculture and oil

production. The total enrollment in Cut Bank's seventh and eighth grade is 142 (Office of Public Instruction, 1986). Cut Bank employs a total of 26 secondary teachers. One instructor, who teaches seventh and eighth grade mathematics and has participated in at least one year of inservice in mastery learning, agreed to participate in this study. This mathematics teacher had taught for 18 years.

Lewistown is a community of 7,100 residents located in central Montana. The economy of the area is based on agriculture and trade. The total enrollment of the seventh and eighth grades in Lewistown is 238 students (Office of Public Instruction, 1986). Twelve teachers teach these two grades. One of the mathematics teachers in Lewistown with 14 years of teaching experience agreed to participate.

Livingston is a community of 6,900 residents located in south central Montana approximately 50 miles north of Yellowstone National Park. The economy is based on lumber, railroading, ranching, and tourism. The total enrollment for the seventh and eighth grades is 226 students (Office of Public Instruction, 1986). One of the mathematics teachers with 16 years of experience participated in the study.

Hardin is located 40 miles east of Billings, Montana. The economy is based on farming and ranching. Hardin is

also impacted by coal mining developments in the area and by its proximity to the Crow Indian Reservation. A portion of the student body is Native American. The total population of Hardin is 3,300 residents. There are 229 students enrolled in the seventh and eighth grades. One of the mathematics teachers agreed to participate in this study and had nine years of teaching experience.

Billings is located in south central Montana and has 67,000 residents. Billings is primarily a trade, medical, and manufacturing center. A mathematics teacher employed by a parochial school, Fratt School, who teaches seventh and eighth grade students and had 19 years of teaching experience agreed to participate in the study. The total enrollment of grades 7 and 8 in this school is 102 students (Office of Public Instruction, 1986).

Bozeman is a community of 21,650 residents in south central Montana 90 miles from Yellowstone National Park. The economy is based primarily on Montana State University which is located in Bozeman. The total enrollment for seventh and eighth grade is 569 (Office of Public Instruction, 1986). One of the mathematics teachers of these grades with 12 years of teaching experience participated in the study.

Fort Benton is located in north central Montana on the Missouri River. The community has 1,700 residents. Fort

Benton is primarily a ranching and farming community. There are a total of 87 students enrolled in grades 7 and 8 (Office of Public Instruction, 1986). A teacher with 18 years of experience participated in this study.

Baker is in southeast Montana and has 2,400 residents. Baker's economy is based on farming, ranching, and oil production. Baker has 98 students enrolled in grades 7 and 8 (Office of Public Instruction, 1986). The teacher participating from Baker had 15 years of teaching experience.

Each of the teachers involved taught two or more classes of seventh or eighth grade mathematics. Instructors were assigned to treatments such that each treatment (control, mastery learning, wait time, and mastery learning with wait time) had approximately the same number of students. The instructors who had received training in mastery learning were assigned to either the mastery learning with wait time or mastery learning treatments. Instructors who had not received training in mastery learning were randomly assigned to either the wait time or control treatments.

Analysis was done independently on each grade because of differences in curriculum at each grade level. The data from the SAT, which included 250,000 students in the norming process, was used to estimate the population

variance (Gardner, Rudman, Karlsen, & Merwin, 1982). The number of students in seventh or eighth grade in Montana is approximately 11,000 (Office of Public Instruction, 1986). The population standard deviation on the SAT subtests is approximately nine units; therefore, the population variance is approximately 81 units. Ott's formula (Mendenhall, Ott, & Scheaffer, 1971, p. 133) was used to determine an approximate sample size.

$$n = \frac{N \sigma^2}{(N-1)D + \sigma^2}$$

N = population size

D = the difference between sample and population mean squared divided by 4.

σ^2 = population variance

n = sample size

A difference of two units between sample and population means ($D = 1$) gave a computed sample size of 80 using Ott's formula. The variance of the mathematics test of the SAT, which included all subtests, was 400. Using this variance, a sample size of 386 students was needed. A sample size of 320 was sought for each grade for generalizations to be made to each grade, seventh and eighth, in Montana.

Definition of Treatments

The content of the seventh and eighth grade classes in the districts included in this study was summarized by the

curriculum guides provided by the districts. The instructors who were in the mastery learning group had used the mastery learning paradigm in their classes. These instructors' use of mastery learning was monitored and assistance was provided as needed by the researcher. The instructors who used wait time received inservice training in wait time. The control group did not receive any training.

To insure that instructors who used wait time in their classrooms understood how to use wait time, the researcher provided a three hour inservice session for the teachers during the summer of 1987 at Montana State University. This inservice involved a review of the research on wait time and practice followed by feedback from the group. A shorter inservice session, in addition to the summer inservice, on wait time was conducted at each site prior to the start of classes in the fall of 1987.

The mastery learning group used only the mastery learning paradigm. Mastery learning is characterized by clear objectives, initial instruction, formative testing, remediation, and corrective and summative testing (Block & Anderson, 1975). Students were told the objectives that were to be mastered and the level of mastery that was expected, usually 80 percent. After initial instruction of no more than 10 hours, a formative task was given to

evaluate the achievement of mastery on the part of the students and instruction on the part of the teacher. If mastery was not achieved by students on the formative task, remediation and reteaching of the students occurred. The remediation and reteaching were different in approach from the original instruction. The students who had received remediation were again tested with a parallel task to the first formative task to see if mastery had been achieved. This remediation and reteaching occurred while class was in session or at a different time. After students had reached mastery, instruction proceeded to a new set of objectives. A summative examination was given at the end of the semester to measure student achievement over all topics covered.

In the wait time group the teacher waited at least three seconds from asking a question to responding in any way (wait time 1). The teacher also waited three seconds or more after a student had spoken (wait time 2). In addition, the teacher was trained in the use of the pausing principle when a lecture format was used in the classroom. The pausing principle (Rowe, 1976) involves a variation of wait time when a lecture format is used. After eight minutes of lecture, students formed triads, groups of three students, which discussed the material presented in the last eight minutes. The students acted as peer tutors with

one another for a period of two minutes. During these two minutes the instructor did not interact with the triads. After the two minutes had expired, the lecture continued. This pattern of eight minutes of lecture followed by two minutes of peer tutoring continued until the end of the lecture. At the conclusion of the lecture all unanswered questions of the triads were addressed by the teacher.

Since the primary emphasis of the triads was upon the material being taught, the members of the triad changed over the course of instruction (Gartner et al., 1971). Classroom management was the key element in the arrangement of the triads. Students who had been discipline problems or had frequently been off-task were not placed in the same triad (Stahlbrand, 1984). Academic abilities of the students were also a consideration in forming the triads. A general mix of academic abilities was sought in the triad. According to Cloward (1976, p. 288), "There is virtually no correlation between a tutor's intellectual credentials and his effectiveness of tutoring." Triads were formed with consideration of personality factors such that the group could function and the potential for growth was present for all the members of the triad (Cloward, 1976).

The mastery learning with wait time group received both the mastery learning paradigm and wait time

treatments. The control group did not use mastery learning and wait time.

Since the mastery learning teachers had successfully implemented mastery learning for at least one year, no inservice was conducted to train the teachers in the use of the mastery learning paradigm.

The reseacher monitored and assisted the instructors involved every three weeks to verify the proper use of the treatments involved. This study began the first week of the 1987-88 school year and concluded at the end of the first semester of the 1987-88 school year in January, 1988.

Methods of Data Collection

Three types of data on the dependent variables were collected from the classes in this study. These data were the raw scores on the advanced form of the Stanford Achievement Test of Mathematics Application Form E (NRT), the researcher generated criterion referenced tests (CRT), which were summative tests over the material covered in the first semester of the topics taught in the mathematics classes in this study for each grade level, and raw scores on the Aiken-Dreger Mathematics Attitude Instrument (ATT). The CRT instruments were different for each grade level. The tables of specifications for the CRT instruments and item response summaries are found in Appendix A. These

three sets of instruments were administered at the start of treatment in September of 1987 and at the conclusion of treatment in January of 1988.

Stanford Achievement Test

The Stanford Achievement Test Advanced Form E Subtest of Mathematics Application (SAT) was used for both pretesting and posttesting in this study.

The Stanford Achievement test was developed as most national norm referenced tests (NRT) with content validity as a primary concern (Gronlund, 1985). Validity for the SAT was established by reviewing many state and local curriculum guides, textbook series, and instructional programs. A table of specifications was prepared from these sources. Items were developed and analyzed on a national basis using 100,000 students from 50 school systems across the country in April of 1980. At the same time, the Otis-Lennon Mental Ability Test was used to aid in establishing validity. Items in the mid-range of difficulty were discarded. Standardization of the test took place in the fall of 1981 and involved 250,000 students in 50 districts. In the standardization process, a sample was drawn which represented the national school population in terms of enrollment, geography, socio-economic status, and public versus private schools.

The SAT measures three major constructs: concepts of numbers, mathematics computation, and mathematics application with 34, 44, and 40 items in each construct, respectively (Gardner et al., 1982). The subtest which measures the construct of mathematics application was the only subtest used in this study. Reliability on the SAT was established by using the Kuder-Richardson Formula #20. The reliability for the mathematics application subtest is .88 and .91 for grades 7 and 8, respectively. The number of items for each category is given to establish content validity for districts using the SAT (Gardner et al., 1982). Table 1 provides a summary of these performance categories for the construct of mathematics applications (Gardner et al., 1982, p. 37).

Table 1. Performance Categories for the SAT

Subtest	Content Cluster	Items
MATHEMATICS APPLICATIONS	Problem Solving	20
	Tables, Graphs, and Functions	8
	Geometry/Measurement	12

Criterion Reference Tests

The nature of NRT presented the possibility that gains in achievement would not be detected as a result of the inadequate sample of items covered in a typical mathematics class (See Table 1). CRTs for each grade level were

developed by the researcher and were used along with the NRT instrument to address this problem. These tests were reviewed by the researcher and teachers during the summer inservice for content validity which had been established by the use of a table of specification in construction.

The reliability of the CRT tests was established using a Kuder-Richardson Formula #20 on the CRT tests administered in January of 1987. The reliability on the CRT test was .8023 for seventh grade and .7181 for the eighth grade.

Aiken-Dreger Mathematics Attitude Instrument

The Aiken-Dreger Mathematics Attitude Instrument (ATT) was originally developed by Aiken and Dreger (1961). This instrument appears in Appendix C. It was constructed by asking 310 college students to write paragraphs on their attitudes towards mathematics. From these 310 paragraphs, Aiken and Dreger synthesized 20 common factors and devised a 20 item instrument using a five point Likert scale. Ten of the items expressed negative attitudes towards mathematics which means scoring is reversed, and 10 items expressed positive attitudes towards mathematics.

In addressing reliability, Aiken and Dreger used a test-retest method which gave a reliability measure of $r = .94$. Validation by Aiken and Dreger was done with a group of 160 college sophomore women enrolled in college algebra

classes (Shaw & Wright, 1967). The ATT is scored from 0-4 for the Likert scale giving a range of scores from 0 to 80.

The ATT has been used by Aiken (1963, 1972, 1974, 1976). The original instrument has been subjected to validity and reliability studies on populations different from the original work of Aiken and Dreger. The instrument was subjected to factorial analysis with white, middle class, middle school students (Silverman, Creswell, & Brown, 1979). The results of this study identified two factors which the ATT measured. The factors that were identified were enjoyment and fear of mathematics.

The ATT was subjected to factor analysis for a population of predominately minority, middle and high school students in California (Adwere-Boamah, Muller, Kahn, 1986). This study involved 2,538 students in northern California. Like Silverman et al. 1979, this study in 1986 identified two factors, those of enjoyment and fear of mathematics. The factors were identified using scree plot and eigenvalues. Together the two factors accounted for 45.5 percent of the total variance with the first factor of enjoyment accounting for 39.7 percent of the total variance. Adwere-Boamah et al. (1986) computed reliability coefficients of .93 for enjoyment and .87 for fear.

The ATT was used in this study as a measure of mathematics attitude because of its demonstrated validity

and reliability across a wide range of students in terms of age, ethnic, and economic backgrounds.

Organization of Data

The data were organized and presented by grade level with descriptive data given first. These descriptive data included the means and standard deviations for both pretest and posttest of the control and experimental groups for the SAT test (NRT), CRT tests (CRT), and Attitude scores (ATT). Tables 27 and 28 in Appendix B contain these descriptive data.

Analysis of variance tables for pretest results are presented first for mastery learning versus no mastery learning crossed with wait time versus no wait time crossed with gender on the NRT, mastery learning versus no mastery learning crossed with wait time versus no wait time crossed with gender for the CRT, and mastery learning versus no mastery learning crossed with wait time versus no wait time crossed with gender for the ATT for each grade level.

Analysis of covariance tables for posttest results are presented for mastery learning versus no mastery learning crossed with wait time versus no wait time crossed with gender on the NRT, mastery learning versus no mastery learning crossed with wait time versus no wait time crossed with gender for the CRT, and mastery learning versus no

mastery learning crossed with wait time versus no wait time crossed with gender for the ATT for each of the grade levels.

Statistical Hypotheses

Type I errors, rejection of a true null hypothesis, and Type II errors, retaining a false null, were considered in this study with a Type II error being of greater concern. A Type I error would result if a true null hypothesis of "no difference exists between the use of mastery learning and mastery with wait time" was rejected. The consequence of this decision would be that students would be subjected to wait time and mastery learning which have no effect on achievement and attitude.

A Type II error would result if a false null hypothesis of "no difference between mastery and mastery with wait time" was retained. In this study a Type II error would occur if there was a difference between mastery learning and mastery learning with wait time but the difference was not detected. A Type II error would have the consequence of withholding an effective method of instruction from students. Therefore, since the consequence of withholding an effective method was of greater importance, the statistical hypotheses that follow

were tested at a significance level of .10. For all statistical tests a p-value was given.

The design of this experiment involved a three factor ANOCOVA using the independent variables: mastery learning, wait time, and gender with three different dependent variables: CRT, NRT and ATT posttest scores which were adjusted using the corresponding covariates of CRT, NRT, and ATT pretest scores. Each ANOCOVA tested the following set of hypotheses for each dependent variable and at each grade level. A total of 42 null hypotheses were tested.

1) Ho: There is no interaction among the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted test score means.

Hi: There is interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted test score means.

2) Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted test score means.

- Hi: There is interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted test score means.
- 3) Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted test score means.
- Hi: There is interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted test score means.
- 4) Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted test score means.
- Hi: There is interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted test score means.
- 5) Ho: There is no statistically significant difference between the adjusted test score means for wait time versus no wait time.

- Hi: There is a statistically significant difference between the adjusted test score means for wait time versus no wait time.
- 6) Ho: There is no statistically significant difference between the adjusted test score means for mastery learning versus no mastery learning.
- Hi: There is a statistically significant difference between the adjusted test score means for mastery learning versus no mastery learning.
- 7) Ho: There is no statistically significant difference between the adjusted test score means by gender.
- Hi: There is a statistically significant difference between the adjusted test score means by gender.

Analysis of Data

This study was concerned with the interaction of the treatments of mastery learning versus no mastery learning, wait time versus no wait time, and the attribute variable, gender. Therefore three way analysis of variance for the pretest data and three way analysis of covariance for posttest data were the methods of analysis (Wiersma, 1986).

A three way ANOVA was done for pretest NRT, CRT, and ATT data for each grade level to determine if equivalence of experimental groups existed for the pretests. The pretest means of the control and experimental groups were statistically different in most cases; therefore, analysis of covariance was used to analyze all the resulting data from the groups using the pretest data as the covariate (Ferguson, 1981). Analysis of covariance was used since treatment groups were unequal at the beginning of this study. The assumptions of equality of variances and a normally distributed population were handled by relying on the robust nature of the F-test (Ferguson, 1981).

Three way ANOCOVAs were used to analyze all of the hypotheses stated. When interaction was found in the analysis, the interaction was checked for ordinal versus disordinal interaction. Type III sums of squares aided in the analysis of interaction and main effects (SAS, 1987). Since this study involved seventh and eighth grades in different school districts, each grade was analyzed independently.

The three way ANOCOVAs tested for each grade were as follows:

Table 2. Variables Used in Analysis of Covariance

Independent Variable	Covariate (pretest)	Dependent Variable (posttest)
1) Mastery X Wait time X Gender	NRT	NRT
2) Mastery X Wait time X Gender	CRT	CRT
3) Mastery X Wait time X Gender	ATT	ATT

All of the dependent data were raw scores on the indicated tests. In the case of the ANOCOVA, raw posttest scores were adjusted with the pretest score as the covariate.

Precautions Taken for Accuracy

The CRTs, ATTs, and NRTs were machine scored using the NCS Century 3000 scanner. Data were placed into a VAX/VMS computer and the computer printout of the raw data was checked against the raw data. All incomplete data sets were deleted. A VAX/VMS computer located at Montana State University was used to analyze the statistical procedures. SAS software was used.

The statistical analysis of the data is presented in Chapter 4.

CHAPTER 4

ANALYSIS OF DATA

Introduction

The data reported in this chapter are organized by grade level with descriptive and inferential analysis for each dependent variable (NRT, CRT, ATT). Each question is answered with the appropriate statistical hypothesis. Cell counts are shown in parentheses for descriptive data.

Analyses of variance (ANOVA) for pretest data and analyses of covariance (ANOCOVA) for posttest data were used to analyze NRT, CRT, and ATT test results. The ANOVAs and ANOCOVAs were completed by using the General Linear Models (GLM) procedure in SAS (1987). The GLM procedure was used because of unequal cell sizes in the data. Type III sums of squares were used in all analyses (SAS, 1987). All ANOVA and ANOCOVA tables involved were presented and after each table the hypotheses were tested and discussed.

Grade 7

A total of 324 seventh graders were pretested in the Fall of 1987. Because some students moved out of the districts during this study, only 289 complete data sets

were used in the analysis of the seventh grade data. This is less than the 320 students desired, but within the range of the sample size requirements. Descriptive summary statistics along with adjusted means from the Analysis of Covariance (ANOCOVA) are presented in Appendix B, Table 27.

Analysis of Grade 7 NRT Data

An analysis of variance, as shown in Table 3, was completed to test the assumption of equality of NRT means in the pretest treatment groups.

Table 3. ANOVA of Grade 7 Pretest NRT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	26.76	26.76	.52	.4702
ML	1	777.22	777.22	15.18	.0001
WT	1	64.25	64.25	1.26	.2635
GENDER * ML	1	25.71	25.71	.50	.4791
GENDER * WT	1	363.30	363.30	7.10	.0082
ML * WT	1	239.21	239.21	4.67	.0315
GENDER * ML * WT	1	2.36	2.36	.05	.8303
ERROR	281	7519.54	26.86		

There was a significant difference among the treatments. The analysis of the interactions (refer to Table 4) of mastery learning and wait time was significant ($p = .0315$) and disordinal with mastery learning with wait time having the largest NRT mean of 26.67.

Table 4. Interaction of ML and WT on Grade 7
NRT Pretest Means

	No Mastery Learning	Mastery Learning
No Wait time	22.18	23.71
Wait Time	21.40	26.67

The interaction between GENDER and WT was significant ($p = .0082$) and is summarized in Table 5. The interaction was disordinal with males with wait time having the largest mean of 25.24 and females had their larger mean in the no wait time group.

Table 5. Interaction of GENDER and WT on Grade 7
NRT Pretest Means

	Males	Females
No Wait Time	22.12	23.81
Wait Time	25.24	22.31

There was a significant difference between the main effects of mastery learning versus no mastery learning ($p = .0001$). The mean for the mastery learning group was 25.05 and for the no mastery learning group, the mean was 21.75.

These statistically significant results on Grade 7 NRT pretest means indicated that differences among the experimental groups existed at the start of treatment in

this study. The statistics concerning main effects and interactions for Grade 7 NRT posttest data are summarized in Table 6. The results are presented for each hypothesis.

Table 6. Grade 7 Analysis of Posttest NRT Means Using ANOCOVA with NRT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	141.60	141.60	5.27	.0224
ML	1	10.65	10.65	.40	.5294
WT	1	26.64	26.64	.99	.3201
GENDER * ML	1	49.67	49.67	1.85	.1749
GENDER * WT	1	3.67	3.67	.14	.7120
ML * WT	1	16.60	16.60	.62	.4323
GENDER * ML * WT	1	11.98	11.98	.45	.5048
ERROR	280	7519.54	26.86		

Ho: There is no interaction among the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no three way interaction among mastery learning, gender, and wait time on adjusted NRT posttest means ($p = .5048$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between mastery learning and wait time on adjusted NRT posttest means ($p = .4323$).

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between gender and wait time on adjusted NRT posttest means ($p = .7120$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between gender and mastery learning on adjusted NRT posttest means ($p = .1749$).

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for wait time versus no wait time.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted NRT posttest wait time means ($p = .3201$).

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for mastery learning versus no mastery learning.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted NRT posttest mastery learning means ($p = .5294$).

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for gender.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference in adjusted NRT posttest gender means ($p = .0224$) with females having an adjusted NRT posttest mean of 25.75 and males having an adjusted NRT posttest mean of 24.34. In looking at actual means, the females began with an actual mean of 23.14 versus 23.71 for the males. At posttest the means were reversed with females having an unadjusted mean of 25.47 versus 24.56 for the males.

Analysis of Grade 7 CRT Data

An analysis of variance was completed to test the assumption of equality of CRT means in the pretest treatment groups. The data are presented in Table 7.

Table 7. ANOVA of Grade 7 Pretest CRT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	5.92	5.92	.22	.6357
ML	1	109.01	109.01	4.14	.0428
WT	1	8.67	8.67	.33	.5664
GENDER * ML	1	.01	.01	.00	.9846
GENDER * WT	1	123.39	123.39	4.69	.0312
ML * WT	1	1.85	1.85	.07	.7912
GENDER * ML * WT	1	7.77	7.77	.30	.5873
ERROR	281	7397.61	26.33		

The only significant interaction on the CRT pretest for Grade 7 was for GENDER and WT ($p = .0312$). This interaction was disordinal (refer to Table 8) with females without wait time having the greater mean of 18.62 and males with wait time having a mean of 18.45.

Table 8. Interaction of WT and GENDER on Grade 7 CRT Pretest Means

	No Wait Time	Wait Time
Males	17.51	18.45
Females	18.62	16.84

There was a significant difference on the CRT pretest for Grade 7 on the main effect of mastery learning, with mastery learning students having a mean of 18.56 versus 17.24 for the no mastery learning students.

The Grade 7 CRT posttest means were analyzed using ANOCOVA and are presented in Table 9.

Table 9. Grade 7 Analysis of Posttest CRT Means Using ANOCOVA with CRT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	118.45	118.45	6.46	.0116
ML	1	103.03	103.03	5.62	.0184
WT	1	278.17	278.17	15.18	.0001
GENDER * ML	1	6.17	6.17	.34	.5621
GENDER * WT	1	33.84	33.84	1.85	.1753
ML * WT	1	11.07	11.07	.60	.4378
GENDER * ML * WT	1	27.92	27.92	1.52	.2181
ERROR	280	5131.56	18.32		

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no three way interaction among mastery learning, gender, and wait time on adjusted CRT posttest means ($p = .2181$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between mastery learning and wait time on adjusted CRT posttest means ($p = .4378$).

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between gender and wait time on adjusted CRT posttest means ($p = .1753$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant interaction between mastery learning and gender in adjusted CRT posttest means ($p = .5621$).

Ho: There is no statistically significant difference between the means of the adjusted CRT test scores for wait time versus no wait time.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference ($p = .0001$) in adjusted CRT posttest wait time means with wait time

having an adjusted mean of 21.69 and the no wait time having an adjusted mean of 19.72.

Ho: There is no statistically significant difference between the means of the adjusted CRT test scores for mastery learning versus no mastery learning.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference ($p = .0184$) in adjusted CRT posttest mastery learning means with mastery learning having an adjusted mean of 21.31 and the no mastery learning having an adjusted mean of 20.10.

Ho: There is no statistically significant difference between the means of the adjusted CRT test scores for gender.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference in CRT adjusted posttest gender means ($p = .0116$). The females had an adjusted mean of 21.35 and the males had an adjusted mean of 20.06.

Analysis of Grade 7 ATT Data

An analysis of variance was completed to test the assumption of equality of ATT means in the pretest treatment groups. The results are given in Table 10.

Table 10. ANOVA of Grade 7 Pretest ATT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	18.20	18.20	.08	.7838
ML	1	3525.40	3525.40	14.60	.0002
WT	1	255.76	255.76	1.06	.3043
GENDER * ML	1	9.15	9.15	.04	.8458
GENDER * WT	1	2.54	2.54	.01	.9184
ML * WT	1	1065.48	1065.48	4.41	.0366
GENDER * ML * WT	1	50.51	50.51	.21	.6477
ERROR	281	67842.94	241.43		

The analysis of ATT pretest means for Grade 7 had a significant interaction for ML with WT ($p = .0366$). Table 11 gives the means for this interaction.

Table 11. Interaction of ML and WT on Grade 7 ATT Pretest Means

	No Mastery Learning	Mastery Learning
No Wait time	50.06	53.29
Wait Time	44.26	55.20

The interaction was disordinal with the mastery learning with wait time having the largest mean of 55.20. There was a main effect for mastery learning that was significant ($p = .0002$) with the mastery learning students having a mean of 54.12 versus 47.12 for the no mastery learning students.

An analysis of covariance, as shown in Table 12, was used to analyze ATT posttest results.

Table 12. Grade 7 Analysis of Posttest ATT Means Using ANOCOVA with ATT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	11.51	11.51	.07	.7964
ML	1	78.93	78.93	.46	.4995
WT	1	124.24	124.24	.72	.3970
GENDER * ML	1	300.17	300.17	1.74	.1884
GENDER * WT	1	118.04	118.04	.68	.4090
ML * WT	1	40.31	40.31	.23	.6293
GENDER * ML * WT	1	763.22	763.22	4.42	.0346
ERROR	280	48346.23	172.67		

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted ATT test scores.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0346$). There was three way interaction among mastery learning, gender, and wait time on adjusted ATT posttest means. The interaction was disordinal with males without mastery learning and wait time having the largest overall adjusted posttest mean of 53.17. The males with mastery learning only had the smallest overall adjusted mean of 46.01. The largest adjusted posttest mean for the females was in the wait time only group with a mean

of 52.06. The smallest adjusted mean for the females was 46.96 for the control group.

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between mastery learning and wait time on adjusted ATT posttest means ($p = .6293$).

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .4090$). There was no two way interaction between gender and wait time on adjusted ATT posttest means.

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .1884$). There was no two way interaction between mastery learning and gender on adjusted ATT posttest means.

Ho: There is no statistically significant difference between the means of the adjusted ATT test scores for wait time versus no wait time.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in ATT posttest wait time means ($p = .3970$).

Ho: There is no statistically significant difference between the means of the adjusted ATT test scores for mastery learning versus no mastery learning.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .4995$). There was no significant difference in adjusted ATT posttest mastery learning means.

Ho: There is no statistically significant difference between the means of the adjusted ATT test scores for gender.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted ATT posttest gender means ($p = .7964$).

Grade 8

A total of 248 eighth graders were pretested in the Fall of 1987. Student movement out of the districts in this study gave 218 complete data sets in January of 1988. This is less than the 320 students desired, but within the range of the sample size requirements. Descriptive summary

statistics along with adjusted means from the analysis of covariance (ANOCOVA) are presented in Appendix B, Table 28.

Analysis of Grade 8 NRT Data

An analysis of variance as shown in Table 13 was completed to test the assumption of equality of NRT means in the pretest treatment groups.

Table 13. ANOVA of Grade 8 Pretest NRT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	112.09	112.09	1.97	.1624
ML	1	1.14	1.14	.02	.8878
WT	1	539.74	539.74	9.47	.0024
GENDER * ML	1	30.59	30.59	.54	.4647
GENDER * WT	1	.13	.13	.00	.9614
ML * WT	1	245.19	245.19	4.30	.0393
GENDER * ML * WT	1	23.55	23.55	.41	.5211
ERROR	210	11972.71	57.01		

The analysis of the Grade 8 NRT pretest means showed a significant two way interaction for mastery learning and wait time ($p = .0393$). The interaction was ordinal with no wait time and mastery learning having the largest pretest NRT mean of 27.73. There was also a significant difference in the pretest NRT wait time means with no wait time having a pretest mean of 25.81 versus 22.86 for wait time. Table 14 summarizes these results.

Table 14. Interaction of ML and WT on Grade 8
NRT Pretest Means

	No Mastery Learning	Mastery Learning
No Wait time	25.41	27.73
Wait Time	24.18	21.51

The ANOCOVA for NRT posttest results for Grade 8 are given in Table 15.

Table 15. Grade 8 Analysis of Posttest NRT Means Using ANOCOVA with NRT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	76.36	76.36	3.28	.0716
ML	1	1.22	1.22	.05	.8193
WT	1	7.79	7.79	.33	.5636
GENDER * ML	1	63.90	63.90	2.74	.0991
GENDER * WT	1	44.72	44.72	1.92	.1673
ML * WT	1	10.90	10.90	.47	.4946
GENDER * ML * WT	1	79.69	79.69	3.42	.0658
ERROR	209	4867.94	23.29		

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, adjusted NRT test scores.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0658$). There was three way interaction among mastery learning, gender, and wait time on adjusted

NRT posttest means. The interaction was disordinal with the females with mastery learning only having the greatest adjusted NRT posttest mean of 29.27. Males with mastery learning only had the smallest adjusted NRT posttest mean of 23.85.

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between mastery learning and wait time on adjusted NRT posttest means ($p = .4946$).

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, adjusted NRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .1673$). There was no two way interaction between gender and wait time on adjusted NRT posttest means.

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, adjusted NRT test scores.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0991$). There was two way interaction between gender and mastery learning on adjusted NRT posttest means. The adjusted means for the two way interaction are given in Table 16. The interaction of the adjusted NRT means was ordinal with females with mastery learning having the greatest adjusted posttest NRT mean of 28.48.

Table 16. Interaction of ML and GENDER on Grade 8 Adjusted NRT Posttest Means

	No Mastery Learning	Mastery Learning
Males	26.83	25.68
Females	26.96	28.84

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for wait time versus no wait time.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted NRT posttest wait time means ($p = .5636$).

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for mastery learning versus no mastery learning.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted NRT posttest mastery learning means ($p = .8193$).

Ho: There is no statistically significant difference between the means of the adjusted NRT test scores for gender.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0716$). There was a significant difference in adjusted NRT posttest gender means with females having an adjusted NRT posttest mean of 27.72 and males having an adjusted NRT posttest mean of 26.25.

Analysis of Grade 8 CRT Data

An analysis of variance was completed to test the assumption of equality of CRT means in the pretest treatment groups. The results are presented in Table 17.

Table 17. ANOVA of Grade 8 Pretest CRT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	6.76	6.76	.33	.5668
ML	1	31.20	31.20	1.52	.2192
WT	1	7.70	7.70	.37	.5410
GENDER * ML	1	3.59	3.59	.17	.6762
GENDER * WT	1	23.94	23.94	1.17	.2817
ML * WT	1	10.85	10.85	.53	.4683
GENDER * ML * WT	1	4.43	4.43	.22	.6429
ERROR	210	4315.09	20.55		

The analysis of Grade 8 CRT pretest means showed no significant differences for interactions or main effects.

An analysis of covariance, as shown in Table 18, was used to analyze CRT posttest results.

Table 18. Grade 8 Analysis of Posttest CRT Means Using ANCOVA with CRT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	.00	.00	.00	.9925
ML	1	68.61	68.61	5.00	.0264
WT	1	97.16	97.16	7.08	.0084
GENDER * ML	1	2.00	2.00	.15	.7029
GENDER * WT	1	11.70	11.70	.85	.3567
ML * WT	1	65.90	65.90	4.81	.0295
GENDER * ML * WT	1	11.34	11.34	.83	.3643
Error	209	2866.11	13.71		

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no three way interaction among mastery learning, gender, and wait time on adjusted CRT posttest means ($p = .3643$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning,

and wait time versus no wait time on the dependent variable, raw CRT test scores.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0295$). There was two way interaction between mastery learning and wait time on adjusted CRT posttest means. Table 18 summarizes the adjusted CRT means for the two way interaction between mastery learning and wait time. The interaction was ordinal with mastery learning having the greatest adjusted CRT posttest mean of 17.13.

Table 19. Interaction of ML and WT on Grade 8 Adjusted CRT Posttest Means

	No Mastery Learning	Mastery Learning
No Wait time	14.56	17.31
Wait Time	14.27	14.30

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between gender and wait time on adjusted CRT posttest means ($p = .3567$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, CRT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant interaction between mastery learning and gender on adjusted CRT posttest means ($p = .7029$).

Ho: There is no statistically significant difference between the means of the CRT test scores for wait time versus no wait time.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference in adjusted CRT posttest wait time means with wait time having an adjusted mean of 14.28 and the no wait time having an adjusted mean of 15.93 ($p = .0084$).

Ho: There is no statistically significant difference between the means of the CRT test scores for mastery learning versus no mastery learning.

Decision: Reject the null hypothesis at the alpha = .10 level ($p = .0264$). There was a significant difference in adjusted CRT posttest mastery learning means. The mastery learning treatment had a larger adjusted posttest CRT mean, 15.80, versus 14.41 for no mastery learning.

Ho: There is no statistically significant difference between the means of the CRT test scores for gender.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no significant difference in adjusted CRT posttest gender means ($p = .9925$).

Analysis of Grade 8 ATT Data

An analysis of variance was completed to test the assumption of equality of ATT means in the pretest treatment groups. The results of this analysis are given in Table 20.

Table 20. ANOVA of Grade 8 Pretest ATT Means

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	123.67	123.67	.42	.5154
ML	1	1492.94	1492.94	5.11	.0248
WT	1	74.87	74.87	.26	.6131
GENDER * ML	1	3.65	3.65	.01	.9111
GENDER * WT	1	3.74	3.74	.01	.9100
ML * WT	1	1397.67	1397.67	4.79	.0298
GENDER * ML * WT	1	31.43	31.43	.11	.7431
ERROR	210	61313.25	291.97		

The only significant interaction ($p = .0298$) for Grade 8 ATT pretest means was for ML and WT. Table 21 presents the results for this interaction.

Table 21. Interaction of ML and WT on Grade 8
ATT Pretest Means

	No Mastery Learning	Mastery Learning
No Wait time	43.13	55.93
Wait Time	48.07	48.45

The interaction was disordinal with mastery learning only having the greatest mean of 55.93. There was also a significant difference in the main effect of mastery learning. The mastery learning group had a mean of 49.85 versus 45.53 for the no mastery learning group.

An analysis of covariance, as shown in Table 22, presents the ATT posttest results. The hypotheses follow Table 22.

Table 22. Grade 8 Analysis of Posttest ATT Means Using ANCOVA with ATT Pretest as Covariate

Source	DF	Sum of Squares	Mean Squares	F value	p
GENDER	1	20.23	20.23	.14	.7131
ML	1	678.04	678.04	4.54	.0342
WT	1	95.79	95.79	.64	.4239
GENDER * ML	1	129.81	129.81	.87	.3520
GENDER * WT	1	379.79	379.79	2.55	.1121
ML * WT	1	94.89	94.89	.64	.4261
GENDER * ML * WT	1	138.04	138.04	.93	.3373
ERROR	209	31187.02	149.22		

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, wait time versus no wait time and gender on the dependent variable, ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .3373$). There was no three way interaction among mastery learning, gender, and wait time on adjusted ATT posttest means.

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and wait time versus no wait time on the dependent variable, ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .4262$). There was no two way interaction between mastery learning and wait time on adjusted ATT posttest means.

Ho: There is no interaction between the independent variables: wait time versus no wait time and gender on the dependent variable, ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level. There was no two way interaction between gender and wait time on adjusted ATT posttest means ($p = .1121$).

Ho: There is no interaction between the independent variables: mastery learning versus no mastery learning, and gender on the dependent variable, ATT test scores.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .3520$). There was no two way interaction between mastery learning and gender on adjusted ATT posttest means.

Ho: There is no statistically significant difference between the means of the ATT test scores for wait time versus no wait time.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .4239$). There was no significant difference in ATT posttest wait time means.

Ho: There is no statistically significant difference between the means of the ATT test scores for mastery learning versus no mastery learning.

Decision: Reject the null hypothesis at the alpha = .10 level. There was a significant difference in adjusted ATT posttest mastery learning means ($p = .0342$). The adjusted posttest ATT mean for no mastery learning was 51.29 versus 46.88 for the mastery learning group.

Ho: There is no statistically significant difference between the means of the ATT test scores for gender.

Decision: Retain the null hypothesis at the alpha = .10 level ($p = .7131$). There was no significant difference in adjusted ATT posttest gender means.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The information reported in this chapter summarizes this study and gives conclusions and recommendations as the result of the research. The conclusions for Grades 7 and 8 are discussed separately. Recommendations include the results of both grade 7 and grade 8.

Summary

This study, conducted from September, 1987, to January, 1988, investigated the effects of mastery learning, wait time, and gender on attitude and student achievement in Grade 7 and Grade 8 mathematics classrooms. A total of 289 seventh graders and 218 eighth graders from the state of Montana were included in this research. These students were taught by nine instructors in nine different communities in Montana.

The students were divided among the basic treatments: control, mastery learning only, wait time only and mastery learning with wait time. Each of these groups were divided by gender.

The teachers involved in this study who practiced wait time received training in the use of wait time during the summer of 1987. The teachers who taught mastery learning groups had used the mastery learning paradigm in their classrooms previous to this study. The control group received no training in either mastery learning or wait time.

All students were given a pretest in early September, 1987, and a posttest in late January, 1988, on three measures: 1) achievement as measured by an NRT, the Stanford Achievement Test, 2) achievement as measured by a CRT, which was developed by the researcher (see Appendix A), and 3) attitude as measured by the Aiken-Dreger Mathematics Attitude Instrument (ATT). The pretest data were analyzed to determine if group means were equal before treatment. The posttest results were analyzed using ANOCOVA using the appropriate pretest as the covariate.

Conclusions

Grade 7

The following conclusions are offered on the analysis of the grade 7 data collected in this study.

- 1) A three-way interaction was found upon analyzing posttest data for the dependent variable of attitude. The interaction was disordinal with the male control group

having the largest overall adjusted posttest mean. The adjusted means were larger for the wait time group, both males and females, and for the male control group. The rest of the groups had lower adjusted posttest attitude means. This interaction demonstrated that without wait time, the attitudes of grade 7 males and females diverged; females had a less positive attitude towards mathematics when wait time was absent. The addition of wait time to mastery learning showed no effect in terms of this interaction in relationship to attitude. The lack of significant main effect differences in the attitude by gender was in agreement with Tsai and Walberg (1983).

This interaction showed that females and males would benefit by the use of mastery learning and wait time in the classroom. Mastery learning and wait time have a positive influence on females' attitudes in grade 7 mathematics, but the treatments did not significantly affect the attitude of males. Therefore, the treatments of this study must have created a condition such that females felt more positive towards mathematics.

2) All the independent variables of mastery learning, wait time, and gender, had significant main effect differences on student achievement at grade 7 as measured by the adjusted posttest CRT means.

Mastery learning was an effective teaching paradigm. The higher achievement attributable to mastery learning was in agreement with many researchers (Block & Burns, 1976; Wise & Okey, 1983; Willet, Yamashita, & Anderson, 1983; Bloom, 1984; Guskey & Gates, 1986).

Wait time had a positive effect on student achievement. The positive effect of wait time was in agreement with Rowe (1974a, 1974b, 1974c, 1986), Tobin and Capie (1982), Swift (1983), Wise and Okey (1983), and Tobin (1986).

Females demonstrated higher achievement on both CRT and NRT measures. This finding was not supported by the research base. Females' achievement as measured by the adjusted posttest NRT and CRT scores was in conflict with Benbow and Stanley (1980), and Geschwind (1982) who concluded that males achieve at a higher level in mathematics.

In conclusion, mastery learning and wait time were effective in positively changing student achievement. Gender was a factor in achievement at grade 7 with females achieving at a higher level.

Grade 8

The following conclusions are given for the results of the analysis of data for Grade 8.

1) On the NRT posttest analysis, which used adjusted means, significant effects were found for gender, the two-way interaction of gender and mastery learning, and the three-way interaction of gender, mastery learning and wait time.

The three-way interaction on the adjusted measures was disordinal. Females had greater achievement when treatment(s) was present. When treatment was absent, female achievement was the lowest. Male achievement was the greatest in the presence of both mastery learning and wait time. The male control group had achievement comparable to the males with both wait time and mastery learning. Therefore, this three-way interaction demonstrated that the treatments of mastery learning and wait time had positive effects on both genders and no treatment had a comparable effect on the male control group.

The two-way interaction of sex and mastery learning on the NRT posttest was ordinal. The interaction showed that females taught by mastery learning had the greatest adjusted mean.

The effects of mastery learning in these two interactions were supported by the works of Block and Burns (1976), Wise and Okey (1983), Willet, Yamashita, and Anderson (1983), Bloom (1984), and Guskey and Gates (1986).

The effects of wait time in these interactions agree with the research base established by Rowe (1974a, 1974b, 1974c, 1986), Tobin and Capie (1982), Swift (1983), Wise and Okey (1983), and Tobin (1986).

Therefore, these interactions showed that both treatments had positive effects on student achievement with mastery learning having had a greater impact on females. These results were similar to the grade 7 attitude posttest results. Treatments were effective for both genders but the removal of a treatment or treatments had negative consequences for females.

There was also a main effect difference with females having a greater adjusted posttest mean on the NRT. This result was consistent with the results for grade 7 where significant differences were found for the NRT and CRT achievement measures. These results were not supported by the research base. Females' achievement as measured by the adjusted posttest scores was in conflict with Benbow and Stanley (1980), and Geschwind (1982) who concluded that males achieve at a higher level in mathematics.

2) On the CRT posttest mastery learning students did significantly better than nonmastery learning students. Mastery learning was an effective teaching strategy. This was in agreement with the analyses conducted by Block and Burns (1976), Wise and Okey (1983), Willet et al. (1983),

Bloom (1984), and Guskey and Gates (1986). Mastery learning showed the greatest effect in the two-way ordinal interaction of mastery learning and wait time.

The grade 8 CRT posttest contradicted the grade 7 results in that no wait time students scored significantly higher than the wait time students. Wait time was not a positive influence on student achievement. This contradicted the research of Rowe (1974a, 1974b, 1974c, 1986), Tobin and Capie (1982), Swift (1983), Wise and Okey (1983), and Tobin (1986).

3) The attitude scores of grade 8 students on the adjusted ATT posttest indicated that nonmastery learning students had the higher ATT mean. Although this is contradictory to the works of Block and Burns (1976), Wise and Okey (1983), Willet et al. (1983), Bloom (1984), and Guskey and Gates (1986), further inspection indicated that mastery learning students remained constant over treatment and nonmastery learning students showed a positive growth in attitude over the course of this study. Mastery learning, therefore, did not affect student attitude at grade 8.

4) The perceived differences in gender achievement, which conclude that males achieve at a higher level, are false. Females in general scored higher on achievement measures at both grade levels. Lack of either wait time

and/or mastery learning, had a negative impact on the achievement and attitude of females.

Although this study did not investigate the scope of grade 8 mathematics curriculum, the inconsistent results of wait time having a negative effect on CRT measured achievement and mastery learning having a negative effect on attitude, which are contrary to the research base, may indicate a curricular problem for grade 8. Rollins (1983), who studied mastery learning in grades 7 and 8, did not find significant differences at grade 8 but found significant differences at grade 7. The results of this study had results similar to Rollins (1983). The results of this study and Rollins' work may be due to the nature of the traditional eighth grade curriculum which is basically a review of the seventh grade mathematics material. The tables of specifications (see Tables 23 and 25) also showed that there are no new strands in the curricula for the first semester for grade 7 and 8. This is consistent with Usiskin's evaluation in 1987 of seventh and eighth grade mathematics curricula. Usiskin concluded that only 30 percent of the material at the eighth grade level was new to the students. Therefore, if only 30 percent of the material is new to students, changes in achievement may be ambiguous and difficult to detect.

Recommendations

Recommendations for Action

1) Teachers of seventh and eighth grade mathematics should be encouraged to implement mastery learning and wait time in their classrooms because of the positive effects demonstrated in this study.

2) This study showed females achieved at higher levels than males on three of the four achievement measures and equal to males on the fourth measure. Typically the expectation is that males will do better in mathematics than females. Educators must be careful not to assume a gender difference in which males achieve more than females. This is in agreement with Fennema and Tartre (1985).

3) Eighth grade mathematics curriculum should be broadened as demonstrated by the inconsistencies found in the results of this study and Rollins' (1983) research. This recommendation is consistent with Usiskin's (1987) conclusions and research.

Recommendations for Further Study

1) This study should be replicated in other states and within a variety of geographical regions. The schools in this study are considered rural and isolated when compared to other schools in the country which would limit the generalizations that could be made to urban areas.

2) Further research should be performed to investigate the possibility of a synergistic effect of wait time and mastery learning. The possibility of a combination of effective treatments to raise student achievement and attitude to higher levels is suggested but not confirmed by this study. The interactions which were not statistically significant for mastery learning and wait time in three of the four achievement measures showed mastery learning with wait time to have the largest adjusted mean.

3) Further research should be performed to investigate the longitudinal effect of mastery learning. Grade 7 students in the mastery learning treatment group performed significantly better on all (NRT, CRT, ATT) pretest measures. These differences cannot be attributed to the treatment in this study since treatment had not begun. However, these students may have had mastery learning at grade 6, since inservice in the use of mastery learning had been offered at some of the schools. These pretest results suggest disagreement with Slavin (1987) who stated that mastery learning had little or no effect as measured by NRT scores. A study which compared achievement and attitude results in the fall of a school year after a year or more of mastery learning compared to no mastery learning could answer the questions these results pose.

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APPENDICES

APPENDIX A

CRITERION REFERENCED TEST INSTRUMENTS

WITH SUMMARY STATISTICS

Student's Name _____

Teacher's Name _____

Criterion Referenced Test for Grade 7

Choose the best answer for the following questions and darken the corresponding letter for that question on the answer sheet. There is one best answer for each problem. You will have 40 minutes to complete this test.

1. The "Hacky Sack" performers gave 22 assemblies during the first four weeks of the year. The next three weeks they gave 13 assemblies. What was the average number of assemblies per week?
 - A) 2
 - B) 3
 - C) 4
 - D) 5
 - E) Not here

2. Each crew member of the shuttle uses .034 of a kilogram of oxygen per hour. How much would seven crew members use of a kilogram of oxygen in one hour?
 - A) .119
 - B) .160
 - C) .238
 - D) .433
 - E) Not here

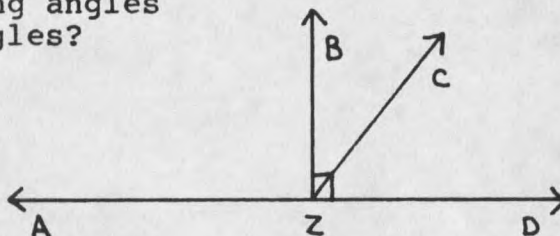
3. Hermina is paid \$40 each day. She works 7 1/2 hours per day. How much is she paid per hour?
 - A) \$5.33
 - B) \$5.00
 - C) \$4.63
 - D) \$4.00
 - E) Not here

4. A stereo's regular price is \$799.00. It is on sale for 20% off. Estimate the amount of the savings.
 - A) \$160
 - B) \$500
 - C) \$700
 - D) \$600
 - E) \$779

5. The least common denominator for $\frac{3}{8} + \frac{5}{6}$ is
- A) 14
 - B) 18
 - C) 24
 - D) 40
 - E) 48
6. Aaron, Sarah, John, and Amanda were paid \$120 for painting a fence. Aaron worked 2 hours, Sarah 4 hours, John 3 hours, and Amanda 3 hours. Compute the wage for each person?
- A) Aaron \$30, Sarah \$30, John \$30, Amanda \$30
 - B) Aaron \$20, Sarah \$40, John \$30, Amanda \$30
 - C) Aaron \$30, Sarah \$60, John \$45, Amanda \$45
 - D) \$70 for Aaron and Amanda, \$50 for John and Sarah
 - E) \$50 for Aaron and Amanda, \$70 for John and Sarah

7. Which of the following angles are complementary angles?

- A) $\angle AZC$ & $\angle CZD$
- B) $\angle BZC$ & $\angle CZD$
- C) $\angle AZB$ & $\angle BZD$
- D) All of the above
- E) Only A & C

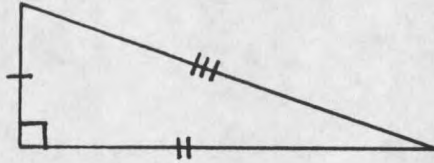


8. Last year, the mileage on Leroy's car was 31,517. He has driven 14,148 miles this year. What is the total mileage on Leroy's car?
- A) 45,665
 - B) 44,615
 - C) 43,616
 - D) 45,611
 - E) Not here

9. The space shuttle has a means of filtering carbon dioxide from the air. A crew of four persons adds 0.156 of a kilogram of carbon dioxide to the cabin's atmosphere in one hour. How much carbon dioxide in kilograms would one person add to the cabin atmosphere in one hour?
- A) 0.039
 - B) 0.044
 - C) 0.116
 - D) 0.624
 - E) Not here
10. Find the difference in the length between a $\frac{3}{4}$ " nail and a $\frac{5}{8}$ " nail.
- A) $\frac{1}{32}$ "
 - B) $\frac{1}{16}$ "
 - C) $\frac{1}{4}$ "
 - D) $\frac{1}{8}$ "
 - E) Not here
11. Which is the best estimate for the difference, $87.8 - 18.9$?
- A) 80
 - B) 70
 - C) 60
 - D) 50
 - E) Not here
12. The prime factorization of 24 is
- A) 2×12
 - B) 3×8
 - C) $2 \times 3 \times 4$
 - D) $2 \times 2 \times 3 \times 2$
 - E) 4×6
13. Sharon makes 5 cents for each paper she delivers. If she delivers 2100 papers in one month, what does Sharon make in one month?
- A) \$62.50
 - B) \$75.00
 - C) \$150.00
 - D) \$105.00
 - E) \$210.00

14. The triangle pictured is a

- A) right triangle.
- B) scalene triangle.
- C) obtuse triangle.
- D) All of the above.
- E) Only A & B.

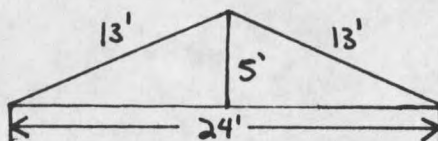


15. The distance from Great Falls to Bozeman is 294.3 km one way. If a college student from Great Falls plans 5 round trips between Great Falls and Bozeman, how many kilometers (km) will this student travel?
- A) 588.6
 - B) 1471.5
 - C) 2943
 - D) 5886
 - E) 29430
16. Given the fact that a person spends $\frac{1}{3}$ of the day sleeping, compute the number of hours a person sleeps in one year. (There are 24 hours in one day and 365 days in one year.)
- A) 8
 - B) 720
 - C) 1095
 - D) 8760
 - E) 2920
17. Which is the best estimate for the sum of 5,189 and 2,201?
- A) 5000
 - B) 6000
 - C) 7000
 - D) 8000
 - E) Not here
18. The greatest common factor of 12 and 18 is:
- A) 2
 - B) 3
 - C) 6
 - D) All of the above
 - E) Only B & C

19. A carpenter is building a roof with the following specifications:

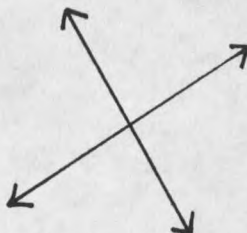
On another building, the same shape is used, but the building spans 12 feet instead of 24 feet. How tall will this new roof be?

- A) 2.5 ft.
 B) 5 ft.
 C) 10 ft.
 D) 12 ft.
 E) 13 ft.



20. The lines pictures are:

- A) intersecting.
 B) skew.
 C) parallel.
 D) perpendicular.
 E) obtuse.



21. The Metra in Billings can hold 10,000 people for a concert. If 2,852 tickets have been sold for a concert, how many more tickets need to be sold to have the Metra full?

- A) 12,852
 B) 7,148
 C) 8,852
 D) 8,148
 E) Not here

22. Rick wants to buy a tape which costs \$10.95. He has \$7.87. How much does Rick have to earn to purchase the tape?

- A) \$3.00
 B) \$3.08
 C) \$7.87
 D) \$10.95
 E) \$18.82

23. Which of the following fraction(s) is (are) equivalent to $\frac{1}{8}$?

- A) $\frac{2}{16}$
 B) $\frac{8}{64}$
 C) $\frac{6}{32}$
 D) All of the above
 E) Only A & B

24. A recipe calls for $5 \frac{1}{3}$ cups flour, $2 \frac{3}{4}$ cups sugar, $1 \frac{1}{4}$ cups oil, and $1 \frac{3}{4}$ cups water. Estimate the total number of cups of ingredients in this recipe.

A) 14
 B) 13
 C) 12
 D) 11
 E) 10

25. What is the least common multiple of 3 and 4?

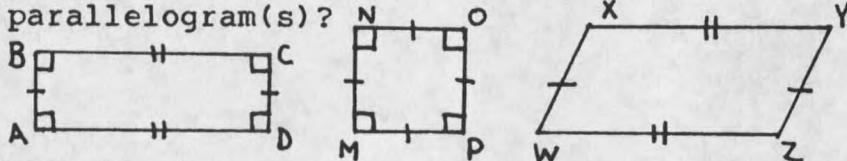
A) 3
 B) 4
 C) 12
 D) 9
 E) 16

26. A store is selling jeans at 30% off the marked price. If the jeans are regularly \$15.00, what will be the sale price?

A) 19.50
 B) 14.70
 C) 12.00
 D) 11.00
 E) 10.50

27. Which of the quadrilateral(s) is (are) parallelogram(s)?

A) ABCD
 B) MNOP
 C) WXYZ
 D) All of these
 E) Only A & C



28. If the 300,000 hunters in Montana each spend \$400 for hunting and hunting related activities, what is the total amount spent on hunting in the state of Montana?

A) \$750,000
 B) \$300,400
 C) \$1,200,000
 D) \$12,000,000
 E) \$120,000,000

29. The seventh grade classes in a school raised a total of \$42.00 in a recycling project. Each class of seventh graders received \$6.00. How many classes of seventh graders are in this school?
- A) 5
 - B) 6
 - C) 7
 - D) 8
 - E) 9
30. Solve $n = 7.826 + 11.94$
- A) 19.766
 - B) 18.766
 - C) 9.020
 - D) 8.020
 - E) Not here
31. The Indianapolis 500 gets its name from the 500 mile long car race that is run on a track $2\frac{1}{2}$ miles around. Last year car number 37 left the race with transmission problems with 50 laps left to complete the race. How many miles had car number 37 gone before it stopped?
- A) 125
 - B) 375
 - C) 400
 - D) 200
 - E) Not here
32. In planning a Halloween party, a student council decided to buy nine pounds of apples at 98 cents per pound, four cases of pop at \$8.65 per case, and six boxes of candy at \$14.90 per box. Estimate the total cost of the food and pop for the Halloween party.
- A) 125
 - B) 130
 - C) 135
 - D) 140
 - E) 145

33. The number 162 is divisible by

- A) 2
- B) 3
- C) 9
- D) All of the above
- E) Only A and B

34. If 3% of the 300 students are absent from school, how many students are in school?

- A) 3
- B) 6
- C) 9
- D) 291
- E) 300

35. Which of these triangle(s) is (are) right triangle(s)?

- A) $\triangle ABC$
- B) $\triangle XYZ$
- C) $\triangle EFG$
- D) All of the above
- E) Only A & C

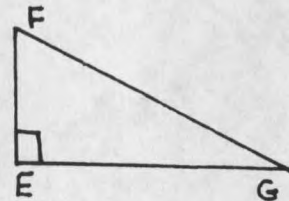
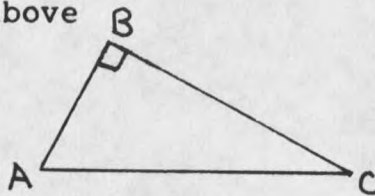
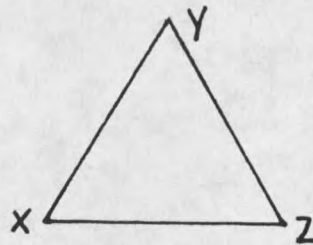


Table 23. Specifications for the Grade 7 CRT Test

Topic	Level		
	Compre- hension	Applica- tion	Analy- sis
Whole Numbers		1, 8, 21, 28, 29	
Decimals		2, 9, 15, 22, 30	
Fractions	23	3, 10, 16	31
Estimation		4, 11, 17 24, 32	
Number Theory	25	5, 12, 18 33	
Ratio & Percent		13, 19, 26	6, 34
Geometry	20, 35	7	14, 27

Table 24. Response Rates and Biserials for the Grade 7 CRT Tests

Item	Biserial r	Number of responses					Omit
		A	B	C	D	E	
1.	.41218	11	12	42	*152	74	4
2.	.34148	3	9	*250	8	25	0
3.	.31404	*130	39	28	19	73	6
4.	.41085	*130	27	38	41	56	3
5.	.41356	39	25	*181	20	27	3
6.	.32004	30	*194	50	9	10	2
7.	.05711	30	*66	117	50	29	3
8.	.33890	*262	5	7	7	14	0
9.	.58495	*180	25	27	23	36	4
10.	.48668	9	25	33	*185	41	2
11.	.48446	14	216	32	10	23	0
12.	.44895	67	15	22	*172	19	0
13.	.38514	6	9	26	*240	14	0
14.	.35834	93	52	30	30	*89	1
15.	.44697	13	128	*99	7	48	0
16.	.51511	10	19	52	55	*154	5
17.	.41156	9	7	*245	14	20	0
18.	.38823	27	19	*178	59	11	1
19.	.45058	*107	52	51	56	25	4
20.	.17280	*250	7	8	18	6	6
21.	.38334	14	*225	9	25	22	0
22.	.30734	5	*278	4	5	3	0
23.	.50505	79	17	9	25	*160	5
24.	.44926	7	15	46	*164	60	3
25.	.36068	5	9	*262	5	10	4
26.	.31112	9	38	85	42	*118	3
27.	.30004	46	32	81	*100	31	5
28.	.45394	6	9	25	33	*219	3
29.	.34812	6	11	*255	13	3	7
30.	.48159	*167	30	37	9	46	6
31.	.15596	60	*66	46	22	90	11
32.	.30817	41	84	*101	27	33	9
33.	.43593	53	12	12	*173	36	9
34.	.21007	19	14	39	*206	5	12
35.	.35300	21	48	75	16	*120	15

* signifies correct answer

Student's Name _____

Teacher's Name _____

Criterion Referenced Test for Grade 8

Choose the best answer for the following questions and darken the corresponding letter for that question on the answer sheet. There is one best answer for each problem. You will have 40 minutes to complete this test.

1. The lava and volcanic ash from an erupting volcano sometimes increase its size. Suppose a volcano erupts five times and doubles its size each time. How many times as large would the volcano be compared to before the first eruption?
 - A) 10
 - B) 16
 - C) 24
 - D) 32
 - E) 64

2. During the landing, the Space Shuttle Orbiter travels about 19.6 kilometers in 3.5 minute. Find the number of kilometers traveled in one minute.
 - A) 1.35
 - B) 1.96
 - C) 3.5
 - D) 5.6
 - E) Not here

3. Today many clocks and watches measure time in seconds. What fractional part of an hour is 20 seconds?
 - A) $1/180$
 - B) $1/120$
 - C) $1/60$
 - D) $1/30$
 - E) $1/15$

4. Mars travels about three miles in $\frac{1}{5}$ of a second of its orbit. How many miles does Mars travel in one second?
- A) $\frac{3}{5}$
 - B) $3 \frac{1}{5}$
 - C) 15
 - D) 45
 - E) 60
5. The least common multiple of 12, 18, and 27 is
- A) 81
 - B) 108
 - C) 216
 - D) 97
 - E) 5832
6. A concession stand is run by the seventh, eighth, and ninth grade students. In one basketball season a total of 126 hours were worked by all the students. The seventh graders worked 36 hours, the eighth graders 48 hours, and the ninth graders worked 42 hours. The profit of \$630.00 must be divided among the grades according to the hours worked. How should the profit be divided?
- A) Seventh \$210, Eighth \$210, and Ninth \$210
 - B) Seventh \$200, Eighth \$230, and Ninth \$200
 - C) Seventh \$180, Eighth \$240, and Ninth \$210
 - D) Seventh \$190, Eighth \$240, and Ninth \$200
 - E) Seventh \$170, Eighth \$250, and Ninth \$210
7. A triangle with sides of lengths of 8, 8, and 16 is __.
- A) isosceles.
 - B) right.
 - C) equilateral.
 - D) not possible.
 - E) acute.

8. In a certain year, Springfield, Missouri, had 103 clear days and 175 cloudy days. The number of partly cloudy days was the difference between 365 and the total number of clear and cloudy days. Find the number of partly cloudy days in Springfield.
- A) 262
 - B) 190
 - C) 128
 - D) 87
 - E) 80
9. The length of an Apollo spacecraft is approximately 17 meters. The length of the Space Shuttle Orbiter is about 37.06 meters. How many times as long as the Apollo spacecraft is the Space Shuttle Orbiter?
- A) 2.18
 - B) 4.18
 - C) 6.18
 - D) 8.18
 - E) Not here
10. Some researchers believe that a person's built-in timing system, or biological clock, may determine the amount of sleep required. A 65-year old adult needs about $5 \frac{1}{3}$ hours of sleep each day. A 5-year old child needs about $10 \frac{1}{2}$ hours of sleep each day. How many more hours of sleep are needed by a 5-year old child than by a 65-year old adult?
- A) 2
 - B) $3 \frac{1}{6}$
 - C) $4 \frac{1}{2}$
 - D) 6
 - E) Not here
11. The Catskill mountain chain in the United States is about 79 kilometers long. The Andes mountain chain in South America is about 17 times as long as the Catskills. Estimate the length in kilometers of the Andes mountain chain.
- A) 800
 - B) 1200
 - C) 1600
 - D) 2000
 - E) 2200

12. Which of the following number(s) is (are) composite numbers?

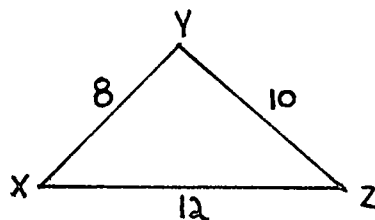
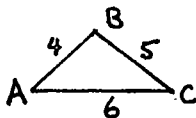
- A) 123
- B) 117
- C) 229
- D) All of these
- E) Only A & B

13. Acme Construction is bidding on a construction job. Acme computed the cost of the building to be 8.5 million dollars. If Acme wishes to make 6% on this job, Acme must submit a bid of _.

- A) 8.50 million dollars
- B) 9.01 million dollars
- C) 9.10 million dollars
- D) 8.56 million dollars
- E) 10.20 million dollars

14. Triangles ABC and XYZ are

- A) congruent.
- B) similar.
- C) equal.
- D) All of the above
- E) Only A & C



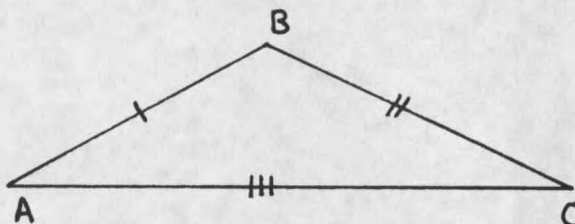
15. The depth of Lake Erie is 210 feet. The depth of Lake Ontario is 592 feet greater than the depth of Lake Erie. The depth of Lake Superior is 1,333 feet. How much greater in feet is the depth of Lake Superior than the combined depths of Lake Erie and Lake Ontario?

- A) 321
- B) 431
- C) 553
- D) 620
- E) 963

16. Using Earth's diameter as one unit, the diameter of Jupiter is 11.27 units and the diameter of Neptune is 3.88 units. How much longer is the diameter of Jupiter than the diameter of Neptune?
- A) 3.88 units
 - B) 5.82 units
 - C) 7.39 units
 - D) 9.96 units
 - E) 11.30 units
17. Find how many minutes there are in $\frac{3}{4}$ of a day.
- A) 360
 - B) 900
 - C) 940
 - D) 1080
 - E) 1200
18. Used cars are on sale for 10% off the regular price. Estimate the sale price of a used car which has a regular price of \$2899.
- A) \$300
 - B) \$290
 - C) \$2,889
 - D) \$2,600
 - E) \$2,500.
19. The number 765 is divisible by __.
- A) 5
 - B) 9
 - C) 45
 - D) All of the above
 - E) Only A & B
20. If Pat can type 135 words in three minutes, how long will it take to type a report which is 1620 words long?
- A) 36 minutes
 - B) 45 minutes
 - C) 54 minutes
 - D) 63 minutes
 - E) 72 minutes

21. Triangle ABC is

- A) obtuse.
- B) acute.
- C) oblique.
- D) All of the above.
- E) Only A & C

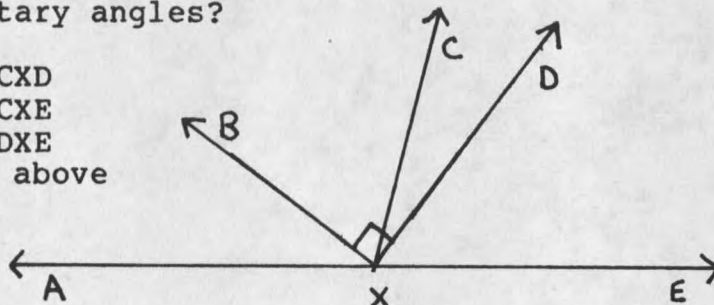


22. A reservoir at Snake River, Idaho, can hold 1,470,000 acre-feet of water. This is 35 times the amount at Boulder Creek, Colorado. How many acre-feet of water can the Boulder Creek reservoir hold?
- A) 32,000
 - B) 42,000
 - C) 51,450,000
 - D) 55,350,000
 - E) None of these
23. The velocity needed for an object to leave the gravitational field of a planet and travel into space is the escape velocity. The escape velocity from Earth is 11.23 kilometers per second. The escape velocity from Saturn is 23.97 kilometers per second more than the escape velocity from Earth. Find the escape velocity from Saturn in kilometers per second.
- A) 25.30
 - B) 35.20
 - C) 11.23
 - D) 46.43
 - E) 52.33
24. Radiocarbon dating is a process used to determine the age of an object. The age is determined by the amount of radiocarbon in the object. An object 10,000 years old has less radiocarbon than an object 1,000 years old. A fossil of a fish contains $\frac{2}{5}$ of its original amount of radiocarbon, a fossil of a bird $\frac{3}{8}$, a fossil of a worm $\frac{2}{3}$, and a fossil of a snake $\frac{1}{4}$. Which fossil is the oldest?
- A) Fish
 - B) Bird
 - C) Worm
 - D) Snake
 - E) Not enough information

25. The populations of the six continents in billions are:
- | | |
|---------------|--------|
| Africa | .436 |
| Asia | 2.4997 |
| Australia | .0143 |
| Europe | .6743 |
| North America | .357 |
| South America | .228 |

Estimate the world's population to the nearest tenth of a billion.

- A) 3.8
 B) 4.0
 C) 4.2
 D) 4.4
 E) 4.6
26. The multiples of 12 are:
- A) 1, 2, 3, 4, 6, 12
 B) 2, 4, 6, 12
 C) 12, 24, 36
 D) 12, 24, 36, ...
 E) 1, 12
27. If eight pencils cost \$.79, how much will 36 pencils cost?
- A) \$3.65
 B) \$3.16
 C) \$2.88
 D) \$3.56
 E) \$3.20
28. Which of the following angles are complementary angles?



- A) $\angle BXC$ and $\angle CXD$
 B) $\angle AXC$ and $\angle CXE$
 C) $\angle AXB$ and $\angle DXE$
 D) All of the above
 E) Only A & C

29. Bell, California, has a population of 25,450. The population of Benecia, California, is 15,376. The population in Bell is stable but the population of Benecia will be twice as much five years from now. Find the difference between the population of Bell and Benecia five years from now.
- A) 3,302
 - B) 4,902
 - C) 5,302
 - D) 6,492
 - E) 7,203
30. At 240 miles per minute, how long does it take a space craft to fly 2,592 miles?
- A) 180 minutes
 - B) 108 minutes
 - C) 1.8 minutes
 - D) 10.8 minutes
 - E) Not here
31. Each month of the Mayan Indian calendar was 20 days long. How many 20 day months would there be in a 365 day year?
- A) 10
 - B) 12
 - C) 14
 - D) 16
 - E) 18
32. Last year Alex earned \$8,859 at one job and \$16,924 at a second job. If Alex's federal income tax rate is 9.8%, estimate Alex's tax bill.
- A) \$800
 - B) \$900
 - C) \$1,600
 - D) \$1,700
 - E) \$2,600
33. Which of the following number(s) is (are) prime?
- A) 179
 - B) 119
 - C) 507
 - D) All if the above
 - E) Only A & B

34. If one puts \$300 into a savings account with simple interest of 7% for three years, how much interest will be earned?

- A) \$21
- B) \$63
- C) \$321
- D) \$363
- E) \$900

35. How many pairs of supplementary angles are in this picture?

- A) 2
- B) 3
- C) 4
- D) 5
- E) 6

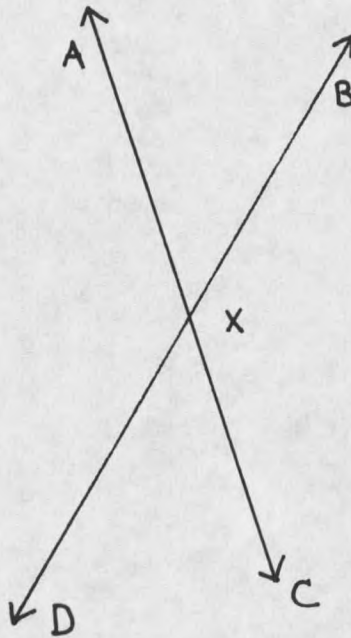


Table 25. Specifications for the Grade 8 CRT Test

Topic	Level		
	Compre- hension	Applica- tion	Analy- sis
Whole Numbers		8, 22,	1, 15, 29
Decimals		2, 9, 16, 23, 30	
Fractions	3	10, 17, 31	24
Estimation		4, 11, 18 25, 32	
Number Theory	12, 26, 33	19	5
Ratio & Percent		13, 20, 27 34	6
Geometry	14, 21		7, 28, 35

Table 26. Response Rates and Biserials for the Grade 8 CRT Tests

Item	Biserial r	Number of responses					Omit
		A	B	C	D	E	
1.	.19255	146	17	16	*29	12	6
2.	.42925	3	16	9	*134	59	5
3.	.34055	*63	47	37	55	21	1
4.	.37290	25	23	*140	17	20	1
5.	.15137	24	*80	48	14	18	42
6.	.38633	25	11	*97	33	59	1
7.	-.00014	103	34	23	*40	25	1
8.	.35079	10	14	8	*183	10	1
9.	.55812	*115	12	10	5	82	2
10.	.42668	7	18	31	16	*153	1
11.	.35162	8	125	*70	14	8	1
12.	.17446	14	26	27	70	*87	2
13.	.31208	46	*59	45	42	29	5
14.	.26967	50	*100	10	44	19	3
15.	.36066	*99	67	39	11	7	3
16.	.38423	7	7	*184	18	8	2
17.	.53297	70	14	36	*89	15	2
18.	.34723	19	39	44	*90	33	1
19.	.35984	39	12	7	*116	50	2
20.	.38723	*141	25	32	11	16	1
21.	.19950	*82	47	34	23	37	3
22.	.36589	8	*128	36	17	35	2
23.	.35853	19	*149	29	20	3	6
24.	.19833	22	64	42	*66	25	7
25.	.40528	26	33	*116	17	28	6
26.	.17897	136	11	9	*57	4	9
27.	.41633	29	52	47	*72	16	10
28.	.04234	72	35	34	39	*31	15
29.	.44295	17	24	*122	22	24	17
30.	.44183	19	23	21	*93	49	21
31.	.34166	15	10	26	22	*111	42
32.	.27977	25	37	45	23	*44	52
33.	.08807	*10	34	26	65	42	49
34.	.22560	59	*56	34	17	11	49
35.	.13353	66	10	*77	8	15	50

* signifies correct answer

APPENDIX B

DESCRIPTIVE DATA TABLES

Table 27. Grade 7 Descriptive Statistics (N = 289)

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Males (n = 149)						
Means	23.71	24.56	17.99	20.13	50.34	49.36
St. Dev.	7.70	7.91	5.38	6.15	15.15	16.53
Adj. Postest Means		24.34		20.06		49.61
Females (n = 140)						
Means	23.14	25.47	17.83	21.24	51.04	50.22
St. Dev.	7.14	7.44	4.94	5.70	16.71	17.36
Adj. Postest Means		25.75		21.35		50.01
No Mastery Learning (n = 143)						
Means	21.79	23.98	17.24	19.57	47.14	47.93
St. Dev.	7.13	7.56	5.11	5.52	15.85	17.77
Adj. Postest Means		25.24		20.10		50.35
Mastery Learning (n = 146)						
Means	25.05	26.00	18.56	21.74	54.15	51.58
St. Dev.	7.38	7.70	5.14	6.18	15.22	15.89
Adj. Postest Means		24.85		21.31		49.27
No Wait Time (n = 151)						
Means	22.99	24.41	18.08	19.91	51.77	49.93
St. Dev.	7.18	8.07	5.43	6.23	14.67	16.19
Adj. Postest Means		24.74		19.72		49.15
Wait Time (n = 138)						
Means	23.92	25.65	17.72	21.49	49.49	49.60
St. Dev.	7.69	7.21	4.86	5.55	17.12	17.73
Adj. Postest Means		25.35		21.69		50.47
Males with No Mastery Learning (n = 75)						
Means	21.79	23.71	17.39	18.95	46.97	48.60
St. Dev.	7.05	7.45	5.16	5.36	14.22	17.23
Adj. Postest Means		24.96		19.31		51.17
Males with Mastery Learning (n = 74)						
Means	25.66	25.43	18.59	21.32	53.77	50.12
St. Dev.	7.88	8.32	5.56	6.68	15.39	15.88
Adj. Postest Means		23.73		20.81		48.04
Females with No Mastery Learning (n = 68)						
Means	21.79	24.28	17.09	20.25	47.32	47.19
St. Dev.	7.27	7.73	5.08	5.65	17.58	18.45
Adj. Postest Means		25.53		20.89		49.52

Table 27--continued.

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Females with Mastery Learning (n = 72)						
Means	24.42	26.60	18.53	22.17	55.54	53.08
St. Dev.	6.83	7.02	4.72	5.64	15.14	15.87
Adj. Posttest Mean		25.97		21.81		50.50
Males with No Wait Time (n = 73)						
Means	22.12	22.90	17.51	18.42	51.30	49.96
St. Dev.	7.61	8.51	5.65	5.96	13.22	14.84
Adj. Posttest Means		23.92		18.72		49.59
Males with Wait Time (n = 76)						
Means	25.24	26.16	18.45	21.76	49.43	48.78
St. Dev.	7.51	6.99	5.09	5.92	16.83	18.09
Adj. Posttest Means		24.76		21.39		49.63
Females with No Wait Time (n = 78)						
Means	23.81	25.82	18.62	21.29	52.21	49.91
St. Dev.	6.69	7.42	5.29	6.18	15.99	17.46
Adj. Posttest Means		25.56		20.71		48.71
Females with Wait Time (n = 62)						
Means	22.31	25.03	16.84	21.16	49.56	50.61
St. Dev.	7.66	7.49	4.42	5.09	17.60	17.38
Adj. Posttest Means		25.94		21.99		51.31
No Mastery Learning and No Wait Time (n = 71)						
Means	22.18	24.21	17.31	18.85	50.06	49.69
St. Dev.	7.31	7.64	5.31	5.50	15.34	17.74
Adj. Posttest Means		25.18		19.31		50.07
No Mastery Learning with Wait Time (n = 72)						
Means	21.40	23.75	17.18	20.28	44.26	46.19
St. Dev.	6.98	7.53	4.93	5.49	15.92	17.76
Adj. Posttest Means		25.31		20.89		50.63
Mastery Learning with No Wait Time (n = 80)						
Means	23.71	24.59	18.76	20.85	53.29	50.15
St. Dev.	7.02	8.48	5.48	6.70	13.97	14.79
Adj. Posttest Mean		24.29		20.12		48.23
Mastery Learning with Wait Time (n = 66)						
Means	26.67	27.73	18.32	22.82	55.20	53.32
St. Dev.	7.54	6.28	4.74	5.35	16.66	17.07
Adj. Posttest Means		25.40		22.49		50.31

Table 27--continued.

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Males Control (No Mastery Learning or Wait Time n = 36)						
Means	21.17	22.83	16.97	17.78	50.31	52.92
St. Dev.	7.65	8.29	5.32	5.23	12.75	15.30
Adj. Postest Means		24.57		18.48		53.17
Females Control (No Mastery Learning or Wait Time n = 35)						
Means	23.23	25.63	17.66	19.94	49.80	46.37
St. Dev.	6.91	6.73	5.36	5.63	17.81	19.61
Adj. Postest Means		25.79		20.13		46.96
Males With Wait Time (n = 39)						
Means	22.36	24.51	17.77	20.03	43.90	44.62
St. Dev.	6.50	6.58	5.04	5.32	14.95	18.12
Adj. Postest Means		25.34		20.13		49.18
Females with Wait Time (n = 33)						
Means	20.27	22.85	16.48	20.58	44.70	48.06
St. Dev.	7.44	8.53	4.78	5.74	17.22	17.41
Adj. Postest Means		25.27		21.65		52.09
Males with Mastery Learning (n = 37)						
Means	23.05	22.97	18.03	19.05	52.27	47.08
St. Dev.	7.57	8.82	5.98	6.60	13.77	13.99
Adj. Postest Means		23.27		18.97		46.01
Females with Mastery Learning (n = 43)						
Means	24.28	25.98	19.40	22.40	54.16	52.79
St. Dev.	6.54	8.02	5.00	6.46	14.25	15.11
Adj. Postest Means		25.33		21.28		50.45
Males with Mastery Learning and Wait Time (n = 37)						
Means	28.27	27.89	19.16	23.59	55.27	53.16
St. Dev.	7.38	7.07	5.12	6.03	16.92	17.21
Adj. Postest Mean		24.18		22.65		50.08
Females with Mastery Learning and Wait Time (n = 29)						
Means	24.62	27.52	17.24	21.83	55.10	53.52
St. Dev.	7.35	5.41	4.03	4.22	16.62	17.19
Adj. Postest Mean		26.61		22.33		50.54

Table 28. Grade 8 Descriptive Statistics (N = 218)

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Males (n = 113)						
Means	24.50	27.17	12.32	14.85	48.25	51.63
St. Dev.	7.66	6.99	4.65	5.01	16.50	15.62
Adj. Posttest Means		26.25		15.11		49.46
Females (n = 105)						
Means	23.52	26.99	11.99	14.34	45.90	47.77
St. Dev.	7.76	6.67	4.43	5.23	17.89	18.15
Adj. Posttest Means		27.72		15.11		48.71
No Mastery Learning (n = 138)						
Means	24.81	27.39	12.60	14.75	45.53	50.19
St. Dev.	7.81	6.99	4.81	5.49	16.64	16.28
Adj. Posttest Means		26.89		14.41		51.29
Mastery Learning (n = 80)						
Means	22.68	26.55	11.40	14.35	49.85	49.05
St. Dev.	7.37	6.54	3.95	4.39	17.86	18.15
Adj. Posttest Means		27.08		15.80		46.88
No Wait Time (n = 86)						
Means	25.81	28.05	12.49	15.29	45.36	47.98
St. Dev.	8.12	7.35	4.80	5.43	17.70	16.83
Adj. Posttest Means		26.75		15.93		48.27
Wait Time (n = 132)						
Means	22.86	26.45	11.95	14.16	48.26	50.94
St. Dev.	7.22	6.41	4.36	4.86	16.81	17.00
Adj. Posttest Mean		27.22		14.28		49.91
Males with No Mastery Learning (n = 68)						
Means	25.19	27.57	12.65	14.90	46.79	52.47
St. Dev.	7.55	6.98	5.24	5.37	16.27	15.99
Adj. Posttest Mean		26.83		14.53		52.62
Males with Mastery Learning (n = 45)						
Means	23.44	26.56	11.82	14.78	50.44	50.36
St. Dev.	7.79	7.04	3.57	4.47	16.78	15.13
Adj. Posttest Means		25.68		15.68		46.31
Females with No Mastery Learning (n = 70)						
Means	24.44	27.21	12.56	14.61	44.30	47.97
St. Dev.	8.09	7.04	4.38	5.65	17.02	16.36
Adj. Posttest Means		26.96		14.30		49.96

Table 28--continued.

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Females with Mastery Learning (n = 35)						
Means	21.69	26.54	10.86	13.80	49.09	47.37
St. Dev.	6.78	5.94	4.39	4.28	19.38	21.54
Adj. Posttest Mean		28.48		15.92		47.46
Males with No Wait Time (n = 40)						
Means	26.13	27.85	12.05	14.93	46.98	49.08
St. Dev.	8.08	7.47	5.23	5.03	16.46	16.28
Adj. Posttest Means		25.45		15.64		47.01
Males with Wait Time (n = 73)						
Means	23.60	26.79	12.47	14.81	48.95	53.03
St. Dev.	7.32	6.73	4.33	5.03	16.59	15.18
Adj. Posttest Mean		27.05		14.57		51.91
Females with No Wait Time (n = 46)						
Means	25.54	28.22	12.87	15.61	43.96	47.02
St. Dev.	8.24	7.33	4.43	5.79	18.77	17.42
Adj. Posttest Mean		28.04		16.22		49.52
Females with Wait Time (n = 59)						
Means	21.95	26.03	11.31	13.36	47.41	48.36
St. Dev.	7.04	6.01	4.35	4.55	17.19	18.82
Adj. Posttest Means		27.40		14.00		47.90
No Mastery Learning and No Wait Time (n = 71)						
Means	25.41	27.82	12.56	14.86	43.13	46.90
St. Dev.	8.33	7.69	4.95	5.63	17.21	16.76
Adj. Posttest Mean		26.93		14.56		49.65
No Mastery Learning with Wait Time (n = 67)						
Means	24.18	26.94	12.64	14.64	48.07	53.67
St. Dev.	7.23	6.19	4.68	5.38	15.75	15.10
Adj. Posttest Means		26.85		14.27		52.93
Mastery Learning with No Wait Time (n = 15)						
Means	27.73	29.13	12.13	17.33	55.93	53.07
St. Dev.	6.99	5.60	4.16	3.83	16.60	16.79
Adj. Posttest Means		26.56		17.31		46.89
Mastery Learning with Wait Time (n = 65)						
Means	21.51	25.95	11.23	13.66	48.45	48.12
St. Dev.	7.00	6.63	3.92	4.24	17.96	18.45
Adj. Posttest Means		27.59		14.30		46.88

Table 28--continued.

	NRT Pre	NRT Post	CRT Pre	CRT Post	ATT Pre	ATT Post
Males Control (No Mastery Learning or Wait Time n = 33)						
Means	25.39	27.94	12.00	14.55	44.97	48.88
St. Dev.	8.23	7.74	5.52	5.05	15.64	16.63
Adj. Postest Mean		27.06		14.67		50.33
Females Control (No Mastery Learning or Wait Time n = 38)						
Means	25.42	27.71	13.05	15.13	41.53	45.18
St. Dev.	8.53	7.74	4.42	6.15	18.52	16.91
Adj. Postest Mean		26.81		14.45		48.97
Males with Wait Time (n = 34)						
Means	24.82	27.09	13.18	15.32	48.06	55.44
St. Dev.	6.99	6.30	5.02	5.76	16.93	14.82
Adj. Postest Mean		26.60		14.39		54.91
Females with Wait Time (n = 33)						
Means	23.52	26.79	12.09	13.94	48.09	51.85
St. Dev.	7.52	6.16	4.30	4.95	14.71	15.40
Adj. Postest Mean		27.11		14.15		50.96
Males with Mastery Learning (n = 7)						
Means	29.57	27.43	12.29	16.71	56.43	50.00
St. Dev.	6.80	6.55	3.90	4.86	18.16	15.72
Adj. Postest Mean		23.85		16.62		43.70
Females with Mastery Learning (n = 8)						
Means	26.13	30.63	12.00	17.88	55.50	55.75
St. Dev.	7.20	4.53	4.63	2.90	16.38	18.30
Adj. Postest Mean		29.27		18.00		50.08
Males with Mastery Learning and Wait Time (n = 38)						
Means	22.32	26.39	11.74	14.42	49.34	50.42
St. Dev.	7.50	7.20	3.55	4.37	16.53	15.24
Adj. Postest Mean		27.50		14.75		48.91
Females with Mastery Learning and Wait Time (n = 27)						
Means	20.37	25.33	10.52	12.59	47.19	44.89
St. Dev.	6.19	5.82	4.34	3.89	20.06	22.11
Adj. Postest Mean		27.69		13.85		44.84

APPENDIX C

AIKEN-DREGER MATHEMATICS ATTITUDE INSTRUMENT

MATHEMATICS ATTITUDE SCALE

Please write your name in the upper right-hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward mathematics. You are to express, on a five point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling.

The five points are:
Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA).

You are to encircle the letter which best indicates how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

- | | | | | | |
|--|----|---|---|---|----|
| 1. I am always under a terrible strain in math class. | SD | D | U | A | SA |
| 2. I do not like mathematics, and it scares me to have to take it. | SD | D | U | A | SA |
| 3. Mathematics is very interesting to me, and I enjoy math courses. | SD | D | U | A | SA |
| 4. Mathematics is fascinating and fun. | SD | D | U | A | SA |
| 5. Mathematics makes me feel secure, and at the same time it is stimulating. | SD | D | U | A | SA |
| 6. My mind goes blank, and I am unable to think clearly when working math. | SD | D | U | A | SA |
| 7. I feel a sense of insecurity when attempting mathematics. | SD | D | U | A | SA |
| 8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient. | SD | D | U | A | SA |
| 9. The feeling that I have toward mathematics is a good feeling. | SD | D | U | A | SA |
| 10. Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out. | SD | D | U | A | SA |
| 11. Mathematics is something which I enjoy a great deal. | SD | D | U | A | SA |

- | | | | | | |
|---|----|---|---|---|----|
| 12. When I hear the word math, I have a feeling of dislike. | SD | D | U | A | SA |
| 13. I approach math with a feeling of hesitation, resulting from a fear of not being able to do math. | SD | D | U | A | SA |
| 14. I really like mathematics. | SD | D | U | A | SA |
| 15. Mathematics is a course in school which I have always enjoyed studying. | SD | D | U | A | SA |
| 16. It makes me nervous to even think about having to do a math problem. | SD | D | U | A | SA |
| 17. I have never liked math, and it is my most dreaded subject. | SD | D | U | A | SA |
| 18. I am happier in a math class than in any other class. | SD | D | U | A | SA |
| 19. I feel at ease in mathematics, and I like it very much. | SD | D | U | A | SA |
| 20. I feel a definite positive reaction to mathematics; it's enjoyable. | SD | D | U | A | SA |

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