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A study to determine the effects that concrete manipulatives have on mathematics anxiety and achievement

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A Study to Determine the Effects that Concrete Manipulatives Have

on Mathematics Anxiety and Achievement

By
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ABSTRACT

Nicholas R. Brian Simione, A Study to Determine the Effects that Concrete Manipulatives Have on Mathematics Anxiety and Achievement, 1995, J. Sooy, Mathematics Education

The purpose of this five week study was to test any effects that concrete manipulatives had on mathematics anxiety and achievement. Two groups of high school freshmen were selected. A control group ($n = 23$) was taught using traditional teaching methods of lecture-homework-review-test. An experimental group ($n = 20$) used concrete manipulatives to reinforce a lesson after it was introduced. Manipulatives replaced worksheets as the sole source of review.

To assess changes in mathematics anxiety in the experimental group, the adolescent version of the Mathematics Anxiety Rating Scale (MARS-A) was administered. The researcher used dependent t test procedures to determine if there was a significant change in mathematics anxiety. Both groups were given a test to assess achievement before and after the experiment. Independent t test procedures were used to determine if there was a significant change in achievement.

Based on t tests there was not a significant difference in mathematics anxiety or achievement.

MINI-ABSTRACT

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Acknowledgments

I would like to acknowledge Dr. John Sooy for his patience, understanding and guidance throughout this experiment. I would also like to acknowledge the administration, faculty and students of Delsea Regional High School for their understanding and participation in this experiment. Finally, and most importantly, I'd like to thank my wife for her support during this time and for her patience while so many jobs went undone around the house.

CHAPTER 1

Introduction to the Study

Introduction

Student achievement in the State of New Jersey is measured each year by the High School Proficiency Test (HSPT). Students who perform poorly on the HSPT are in jeopardy of not obtaining a high school diploma. Research has shown that students with high mathematics anxiety tend to score lower on mathematics achievement tests (Clute, 1984). Greenwood (1984) asserts that teacher methodology can lead to mathematics anxiety. The objective of this experiment was to study the changes in mathematics anxiety and achievement if manipulatives were incorporated into teacher methodology.

Background of the study

A student enrolled in a remedial mathematics class is required to pass the same HSPT as a student enrolled in a college preparatory class. Typically, remedial students have experienced repeated failure in mathematics and have developed a dislike for mathematics. For some, dislike has progressed into fear. Teachers are given the task of insuring student success on the HSPT and the difficulty of this task is compounded by the students' fear of mathematics.

Generally there are two terms that describe mathematical fear:

mathematics anxiety and mathphobia. Mathematics anxiety is not the same as mathphobia. Mathphobia is an irrational fear of mathematics. Often mathphobia requires clinical treatment by trained professionals. "Math anxiety can be described simply as a fear of doing anything mathematical" (Crawford, 1980, p. 9). Mathematics anxiety results in mathematics avoidance. Mathematics avoidance keeps people from enjoying different activities and they become dependent on others. There are many reasons why students develop mathematics anxiety. The "explain-practice-memorize" style of teaching is one of the causes of mathematics anxiety (Greenwood, 1984; Tobias, 1976; Williams, 1988). Given that teaching style can cause mathematics anxiety, teaching style can overcome mathematics anxiety.

Often, mathematics learning is a function of teaching style. Manipulatives, if incorporated properly into teacher methodology, will reduce mathematics anxiety (McCoy, 1990; Suydam, 1984). The use of concrete manipulatives may also create an anxiety-free classroom (Martinez, 1987). An anxiety-free classroom promotes enjoyment of mathematics and improves achievement.

Problem

The purpose of this study is to determine the effects of concrete manipulatives in the secondary mathematics classroom. Specifically, will manipulatives reduce mathematical anxiety and increase mathematical achievement. Two hypotheses were tested.

H_o: There will be no significant difference in mathematical achievement between the control group and the experimental group.

H_o: There will be no significant change in mathematical anxiety in the experimental group.

Significance of the problem

Student achievement in New Jersey is measured each year by a state-mandated test known as the HSPT. Regular education students cannot obtain a high school diploma without meeting the state required minimum standard set for the HSPT. The New Jersey State Department of Education mandates that an Early Warning Test (EWT) be given in the eighth grade to identify those students who may have difficulty achieving the state minimum requirement on the HSPT. Public secondary schools have established a variety of methods to prepare students for the HSPT. Preparatory classes, for those students who have been identified by the EWT as possibly having difficulty passing the HSPT, have been established to supplement a regular mathematics class.

Both those who teach preparatory and regular mathematics classes, should be concerned with the mathematical achievement of the students. Specifically, what are the causes and/or reasons of poor achievement on the HSPT. Mathematics anxiety has been found to have a negative effect on mathematics achievement (Clute, 1984; McCoy, 1990; Tobias, 1987). "Mathematics anxiety is both the emotional and cognitive dread of mathematics" (Williams, 1988, p. 96). Tobias (1976) refers to mathematics anxiety as an "I can't" syndrome. This syndrome can cause students to avoid mathematics because they feel they are unable to do the mathematics.

Researchers have suggested many ways to reduce mathematics anxiety. Crawford (1980) suggest support groups for adults and college students. For adolescents, use of manipulatives as an instructional tool has been proven to be effective. "Where as adolescents are at the threshold of abstract reasoning, they are not able to sustain this level of thinking. They need to work with physical models from which they can then abstract mathematical ideas using symbols" (Morris, 1981, p. 416). Manipulatives are the physical models that meet those needs.

Limitations

This study was conducted in one high school, located in Southern New Jersey. The school is a regional school with nine hundred sixty-seven lower to middle-class students. Two sections of Transition One mathematics classes were used for this study. The experimental group met at 7:45 a.m. and the control group met at 1: 42

p.m. The teacher factor was held as a constant since the same teacher taught both groups before, during and after the experiment.

Definitions

24-game: Square cards with four numbers ranging from one to nine. The object of the game is to manipulate the four numbers using any mathematical operation and obtain an answer of twenty-four.

Algebra Tiles: Plastice square tiles that are numbered zero through nine. There is an accompanying activity book with activity sheets which require students to use the tiles to perform an array of mathematical tasks. A sample problem might be (Ò + 3) - 6 = Ò. Students are to replace Ò with an algebra tile to form a true statement. There several algebraic skills that are addressed through these activities.

Concrete Manipulatives: Physical objects that can be used to demonstrate abstract mathematical concepts. This experiment used rainbow cubes, 24-game, algebra tiles and geo-boards for concrete manipulatives.

Control Group: A group of twenty-three Transition One mathematics students that were taught using the following teaching methods: lecture, guided practice, independent practice, teacher demonstration and weekly visits to a computer lab.

Experimental Group: A group of twenty Transition One mathematics students that were taught using the same teaching methods as the control group. However, the lecture was supplimented by the group's use of concrete manipulatives.

Geo-boards: These are square plastic boards with pegs arranged in a ten by ten square. Students can used rubber-bands on these boards to form shapes, count area and perimeter, and form patterns.

Rainbow Cubes: These are brightly colored cubes measuring one centi-meter on each side. Students can arrange these cubes to form shapes or count volume.

Regular Education Student: A non-classified student, these students do not have specific needs that require state mandated supplementary instruction.

Transition One mathematics: This is the lowest level of regular education mathematics class that is offered to students. It is comparable to a general mathematics class however, the curriculum mandates that skills tested on the HSPT are also taught in this class.

Procedures

This experiment was conducted in four phases. The first phase was pre-assessment. The pre-assessment measure for mathematical achievement was the unit test from the previous chapter. This unit test was a combination of a teacher produced test with a test that was provided in a teacher resource kit that comes with the Transition

Mathematics textbook. The content tested by the unit test was on measurement. This was different then the content taught during the experiment. The content taught during the experiment covered patterns and variables. The researcher believed that the unit test on measurement served as a valid instrument for pre-assessment of mathematical achievement because of the following reasons. This experiment began midway through the school year. Both groups were taught by the same teacher using the same methods. It was assumed that levels of mathematics achievement and anxiety would be constant in both groups becuase of methods of instruction, and the difference in content would not effect the outcome. An attitude measure was administered to the experimental group to determine mathematics anxiety.

The instrument that was used to measure mathematics anxiety was an adolescent version of the MATHEMATICS ANXIETY RATING SCALE (MARS-A). "... MARS is the most frequently used measure of math anxiety ..." (Meece & Wigfield, 1988, p. 210). Some claim that MARS is "... the best instrument for measuring mathematics anxiety that is currently available " (Williams, 1988, p. 99). Several educational researchers support MARS-A, an adolescent version of MARS, as an accurate measure of mathematics anxiety.

The second phase was the experiment itself. During this phase, all forms of teacher methodology mentioned in the definition of "control group" were held as constants. The use of concrete manipulatives by the experimental group was the variable that was tested. The experiment began on January 30, 1995 and terminated on March 3, 1995. The sample population for this experiment was forty-three regular education students. Twenty participated in the experimental group and twenty-three participated in the control group. A unit lesson on patterns and relations was taught to both groups.

The third phase was post-experiment assessment. To assess achievement, both groups were given a posttest. MARS-A was readministered to the experimental group to assess change in mathematics anxiety.

The fourth phase was data analysis. Dependent t test procedures were used to analyze data gained from the MARS-A (pre-assessment and post-assessment). The results were then compared to determine if there had been a significant change in mathematics anxiety. Independent t test procedures were used to analyze data from the pretest and posttest measure of mathematical achievement. Alpha was set at 0.05 . The results were compared to determine if a significant difference in mathematical achievement exsists between the control and experimental groups.

CHAPTER 2

Related Research and Literature

Introduction

Student achievement in the State of New Jersey is measured each year by the High School Proficiency Test (HSPT). Students who perform poorly on the HSPT are in jeopardy of not obtaining a high school diploma. Research has shown that students with high mathematics anxiety tend to score lower on mathematics achievement tests (Clute, 1984). Greenwood (1984) asserts that teacher methodology can lead to mathematics anxiety. The objective of this experiment was to study the changes in mathematics anxiety and achievement if manipulatives were incorporated into teacher methodology. This chapter will explore and discuss the related research and literature.

Related Literature

In 1978, Sheila Tobias introduced mathematics anxiety to the general public with her book, Overcoming Math Anxiety, which was written to help adult women overcome their mathematics anxiety, and encourage women to get involved in careers that utilize mathematics. She explained that women have traditionally avoided mathematics, limiting their career choices and opportunities.

Tobias (1978) and Crawford (1980) both disagree with the notion of a "math mind". That is the concept that some are born with the ability to do mathematics while others are not. Moreover, they disagree with the assertion that men are naturally better mathematicians. The reason for any discrepancy in mathematical achievement between males and females is due to the difference in mathematics preparation. "One study by sociologist Lucy Sells, found a large discrepancy in the background of male and female freshmen at Berkeley. Her results showed that fifty-seven percent of the boys had taken four years of high school math, while only eight percent of the girls had such backgrounds" (Crawford, 1980, p. 12). Women fear and avoid mathematics for sociological, not biological, reasons.

People, in general, develop mathematics anxiety. Poor mathematics teachers, poor teaching methods, an insufficient number of mathematics courses, unintelligible texts, misinformation about what mathematics is and misinformation about who should do well in mathematics are causes of mathematics anxiety (Crawford, 1980; Greenwood, 1984; Tobias, 1978).

In 1987, Tobias wrote, Succeed with math: Every student's guide to conquering math anxiety, a book that addresses a more general audience. This is a self-help book that places the responsibility of overcoming mathematics anxiety on the individual. The first few chapters describe and explain mathematics anxiety. The remainder of the book, looks at different branches of mathematics and offers suggestions on how to approach mathematics without anxiety. "The chapter on problem solving seems particularly useful. Mathematics without the ability to apply those sets of skills to problem solving is probably useless. The student then may perceive of mathematics as being useless, therefore, increasing their boredom, and anxiety seems likely to increase" (Blackburn, 1988, p.393). The book attempts to influence reluctant students to persue mathematics by encouraging them to take certain steps to overcome mathematics anxiety. The book itself may be an obstacle. There are several mistakes including an inconsistent level and the coverage of topics (Lieblich, 1993). For students who are already fearful of mathematics, these flaws may increase their mathematics anxiety.

While authors such as Tobias and Crawford offer advice for students to help themselves conquer mathematics anxiety, others, such as Greenwood (1984), look at mathematics anxiety differently. He writes that "mathematics anxiety is an equal-opportunity affliction" (p. 662). He disagrees with those who maintain that women and minorities are the ones who suffer the most because of genetic or social reasons. "The major source of math anxiety lies in the impersonal, nongrowth, nonrational methodologies that are characterized by the 'explain-practice-memorize' paradigm" (Greenwood, 1984, p. 663). Since teaching methodology can lead to mathematics anxiety, teaching methodology may also cure mathematics anxiety.

There are many options for teachers. Manipulatives are suggested by several authors. For young minds that are still in the concrete-operational stage of cognitive development, manipulatives are ideal for teaching mathematical concepts. For students in the early stages of the formal-operational stage of cognitive development, there may be an inherent distrust of thinking without manipulation. This distrust may develop into mathematics anxiety. Manipulatives provide an easy transition from the concrete-domain to the abstract without fear or anxiety.

The NCTM standards (1989) strongly advocate the use of manipulatives to increase mathematical achievement. "Lessons using manipulative materials have a higher probability of producing greater mathematics achievement than do lessons in which such materials are not used. This finding presumes that using manipulatives is plausible in a lesson - they can't be used with all topics for all purposes" (Suydam, 1984, p. 27). Manipulatives involve students in the learning process and reguardless of the child's stage of cognitive development, manipulatives, if properly incorporated, will increase understanding.

Related Research

Mathematics Anxiety. There are several theories on how mathematics anxiety should be treated. These theories range from support groups and self-help techniques, such as a "Bill of Rights", to various teaching methods. This section will consider a few of these and report on the findings.

Formica (1983) conducted an experiment using two groups of ninth grade students. The control group was taught using the course textbook and homework in a traditional manner. The experimental group participated in a mathematics lab. The mathematics lab consisted of computer aided activities, a Dukane machine and a Hoffman machine. The Dukane machine required students to watch a filmstrip, listen to cassette tapes and , after performing those two tasks, the students completed a work sheet. On the Hoffman machine, students listened to a record and watched a filmstrip while, at the same time, doing a worksheet. The students went to the mathematics lab once a week for eight weeks.

The participants in this experiment were pretested to determine their levels of mathematics anxiety and achievement. After the experiment, both groups were posttested to determine if there were changes in anxiety and achievement.

The findings of this experiment showed that there was not a significant difference in mathematics anxiety between the experimental group and the control group.

Kitchens (1979) studied the effects of Stress Innoculation Training on randomly selected college mathematics students at Appalachian State University. Stress Innoculation Training is a cognitive-behavioral treatment approach to mathematics anxiety (Scheider & Nevid, 1993). A control group was taught without using Stress Innoculation treatments while the experimental group was given such treatments. The results of this study showed there was not a significant difference between the two groups.

By comparison, Schneider & Nevid (1993) state, "Stress Innoculation Training, a systematic desensitization, treatment results in significant lower math anxiety ratings..." (p. 286). The results of these two studies are in direct conflict with each other. Suydam and Higgins (1977) address a similar conflict. They cite twenty-three studies in which changes in mathematics attitude (anxiety) and mathematics achievement were tested when concrete manipulatives were used in the classroom. Of the twenty-three studies, two favored not using manipulatives; eleven favored using manipulatives; ten showed no significant difference. They concluded that the method in which manipulatives were incorporated into the lesson had an effect on the results. Manipulatives had to be used correctly if the desired result was to be achieved.

Drapac (1980) tested twenty-eight remedial college mathematics students for three and half weeks. The experiment tested the effect math tile manipulatives had in improving mathematics achievement and decreasing mathematics anxiety. The results of the one-tailed t test, with alpha < 0.001, showed increased achievement and decreased anxiety.

Mathematics Achievement. Greenberg (1992) tested the effectiveness of algebra-tile manipulatives on twenty eighth-grade algebra students. A sub-sample of six students were interviewed before, during, and after the experiment. The entire sample was given a posttest and results were compared with results from previous years. "The use of manipulatives in teaching mathematics has been shown to increase understanding of concrete concepts" (Greenberg, 1992, p. 21). The findings in the Greenberg study concur with the previous statement. The sample attained scores 18.31 and 6.48 higher then the previous two years.

Canny (1983) examined whether manipulatives had more of an impact introducing a concept, reinforcing a concept, or both. This study used four experimental groups. Group A (n=41) used manipulatives to introduce the first lesson of a concept. Group B (n=27) used manipulatives after the first lesson with the introduction to the lesson accomplished through traditional means. Group C (n=28) used manipulatives to introduce a concept, then, they practiced the same concept using textbooks. Afterwards, the concept was reinforced using manipulatives. Group D (n=27) served as the control group with no manipulatives used.

Two measures were used to assess achievement: the Science Resource Associates (SRA) Achievement test and a researcher designed achievement and retention test. The SRA showed there was not a significant difference between the four groups. The researcher designed tests showed that Groups A and B were significantly higher than groups C and D.

CHAPTER 3

Procedures

Introduction

Student achievement in the State of New Jersey is measured each year by the High School Proficiency Test (HSPT). Students who perform poorly on the HSPT are in jeopardy of not obtaining a high school diploma. Research has shown that students with high mathematics anxiety tend to score lower on mathematics achievement tests (Clute, 1984). Greenwood (1984) asserts that teacher methodology can lead to mathematics anxiety. The objective of this experiment was to study the changes in mathematics anxiety and achievement if manipulatives were incorporated into teacher methodology. This chapter will explain, in detail, the procedures followed during this experiment.

This experiment was conducted in four phases. The first phase was pre-assessment. The second phase was the experiment itself. During the experiment, all forms of teacher methodology mentioned in the definition of "control group" were held as constants. It was the use of concrete manipulatives by the experimental group that was the variable which was tested. The experiment lasted for five weeks. The sample for this experiment was forty-three regular education students. Twenty participated in the experimental group and twenty-three participated in the control group. A unit lesson on patterns and variables was taught to both groups. The third phase was post-experiment assessment in which both groups were given a posttest. MARS-A was readministered to the experimental group to assess change in mathematics anxiety. The fourth phase was data analysis. Dependent t test procedures were used to analyze data gained from the MARS-A (pre-assessment and post-assessment). The results were then compared to determine if there had been a significant change in mathematics anxiety. Independent t test procedures were used to analyze data from the pretest and posttest measure of mathematical achievement and alpha was set at 0.05. The results were compared to determine if a significant difference in mathematical achievement was noted.

Methods of Pre-assessment. The pre-assessment measure for mathematical achievement was the unit test from the previous chapter. This unit test on measurement was a combination of a teacher-produced test with a test that was provided in a teacher resource kit that comes with the Transition Mathematics textbook. Although the content of this pre-assessment instrument was different than the content used for the experiment, the researcher believed that it could serve as valid pre-assessment of mathematical achievement because of the following reasons. This experiment began midway through the school year. Throughout the school year, both groups were taught by the same teacher using the same methods. It was assumed that levels of mathematics achievement and anxiety would be constant in both groups because of methods instruction were the same for both groups; therefore, the difference in content would not affect the outcome.

An attitude measure was administered to the experimental group to determine mathematics anxiety. The instrument that was used to measure mathematics anxiety was an adolescent version of the MATHEMATICS ANXIETY RATING SCALE (MARS-A). The adult version of this measure is MARS. Gliner (1987), Clute (1984), and Williams (1988) are some of the researchers that have used MARS-A and MARS.

MARS-A is the most frequently used measure of mathematics anxiety. It is a ninety-eight-item opinionnaire developed by Suinn and Edwards (1982) that measures the individual's feelings which they experience during certain situations involving mathematics. Most of the questions specifically target numerical anxiety and a few questions target test anxiety. A detailed analysis of the internal consistancy of MARS and MARS-A states the following:

> The MARS-A have obtained somewhat mixed results. In Richardson and Woolfolk's (1980) factor analysis of the MARS, one

> major factor emerged. This factor may be characterized best as an emotionality factor, insofar as the MARS is primarily a measure of negative affective reactions to mathematics. By contrast, Rounds and Hendel (1980) found evidence for two factors in their analysis of responses to the MARS. They labeled one factor Math Test Anxiety and other Numerical Anxiety, the latter referring to anxiety about math in everyday situations. Each factor contained about an equal number of items. Suinn and Edwards (1982), using the MARS-A, also found evidence for these two factors, though 89 of 98 items loaded on the Numerical Anxiety factor and only 9 on the Test Anxiety factor. However, these two factors distinguish between negative affective reactions in nonevaluative versus testing situations not between affective and cognitive aspects of math anxiety (Wigfield & Meece, 1988, p. 210).

Students in a Transition Mathematics I class have typically had difficulty with numerical concepts and testing situations. Since MARS-A asks specific questions on those two areas, it was a valid and reliable measure to use in this study.

Selection of Sample. The sample of students participating in this study represents all ninth and tenth grade regular education students who are not on a college preparatory track of mathematics education. Two Transition Mathematics I classes were selected whose population at the beginning of the experiment totaled forty-three students. Twenty students formed the experimental group and twenty-three students formed the control group. These students have either selected Transition Mathematics I voluntarily or were forced to take this class because a lower level of mathematics is not offered to ninth or tenth grade students. There are seven participants who are taking this class again because they failed the previous year. Six of those students are in the control group. The experimental group met from 7:45 a.m. to 8:29 a.m. and the control group met from 1:41 p.m. to 2:24 p.m. The students were unaware that they were participating in an experiment.

Procedures

The lessons taught during the experiment, typically, took two days. On day one, the lesson was introduced to both groups. On day two, reinforcement of the lesson was provided. For the experimental group, reinforcement was provided by means of a manipulative activity. For the control group, reinforcement was provided by means of worksheets and notes taken from the teacher's lecture.

There were many options for the incorporation of manipulatives into the lessons. When deciding just how to incorporate manipulatives, one must consider the individual needs of the students and the appropriate amount of time that students should use manipulatives (Suydam, 1984). Educators may use manipulatives to introduce a topic, to reinforce a lesson, or some may opt to use manipulatives in both situations. If manipulatives are used to introduce a lesson, or to reinforce a lesson, students will score significantly higher on researcher-designed tests than students who used manipulatives in both situations or students who did not use manipulatives at all (Canny, 1983). This study will use manipulatives to reinforce a lesson.

During this experiment, a unit on patterns and variables was taught to students in both groups. The topic of the first lesson was orders of operations. There were two objectives as follows:

1) that students would know the correct order of operations; and
2) that students would be able to apply them in evaluating numerical expressions properly.

The lesson was introduced to students in both groups who were asked to think of the process of putting on a pair of shoes. It was stressed to the students that this process would not yield the same result if it were done in a different order. It was then stressed to the students that numerical expressions also need to be performed in a certain order. The order of operations was then presented. From that point, several examples were given and guided practice was provided.

The next day the lesson was reinforced. For the control group, this was accomplished through review of their homework assignments. Further guided practice was provided by means of a worksheet. This worksheet, known as Lesson Master 4-1, was part of the teacher resource kit that accompanies the Transition Mathematics textbook. The experimental group also reviewed their homework assignments. However, instead of using Lesson Master 4-1, students used the 24-game. The 24-game is a set of cards with four numbers. Students are to combine the four numbers to arrive at an answer of twenty-four. Students chose a card from the deck, considered the four numbers, stated the solution verbally and then they had to write the solution. A second activity was also used to provide reinforcement for the experimental group. Algebra tile manipulatives were used along with an activity sheet which is included as part of the resource kit. Equations such as $6 \times 5 \div [\ ] - 2 = 8$ required students to replace [ ] with an algebra tile numbered zero through nine. There were five equations on each sheet, and each student completed two sheets. Closure was provided for both groups by summarizing the order of operations.

The topic of the second lesson, describing patterns with variables, had three objectives. Given an example of a pattern, students wrote a description of that pattern. Students gave examples of a pattern described with variables, and, then, given examples of a real world pattern, students wrote a description of the pattern using variables.

The lesson was introduced to both groups by means of a challenge problem. The problem was stated as follows: There were several sections in a certain zoo. The first section had one animal, the second section contained three animals, and the third section contained five animals. If animals were placed in each section following the same pattern, how many animals would be in the tenth section? The students were then taught how to form a table from the given information, answer the question and then express the pattern in terms of a variable. A few more examples were given to provide guided practice and then a homework assignment was given to provide independent practice.

The next day the lesson was reinforced. For the control group, this was accomplished through review of their homework assignments. Further guided practice was provided by means of a worksheet, known as Lesson Master 4-2, which was part of the teacher resource kit that accompanies the Transition Mathematics textbook. The experimental group also reviewed their homework assignments. However, instead of using Lesson Master 4-2, reinforcment of the lesson was provided by means of rainbow cubes and the accompanying activity sheets. Three specific activity sheets were chosen "Patterns 3", "Patterns 5" and "Patterns 6" (Charles, 1990). These three activity sheets required students to construct patterns with the rainbow cubes. The first three shapes in the sequence were given and students had to predict how many cubes it would take to construct the tenth shape, the hundredth shape and then the nth shape. Closure was provided to both groups by reviewing key terms of the lesson and by having the students write a summary of the lesson.

The control group also needed a lesson on translating algebraic expressions and used Lesson Master 4-3. For the experimental group, translating algebraic expressions was a natural extension from the manipulative activities; therefore, there was not a formal lesson. The teacher provided feedback and correctives as the students performed the given tasks.

The topic of the third lesson was evaluating algebraic expressions where the objective of the lesson was for students to be able to evaluate algebraic expressions given the values of all variables. The lesson was introduced to both groups by having the students compare temperatures, such as the boiling and freezing points of water, in Celsius and Fahrenheit. They were given an opportunity to verbally make other observations from their own experiences involving temperatures and the difference between Celsius and Fahrenheit. Afterwards, they were shown the formula $C = {}^{5}/_{9}(F - 32)$. The teacher explained to them how to evaluate this algebraic expression. Both groups were then given key terms and some examples for guided practice. Finally, a homework assignment was given to provide independent practice.

The next day the lesson was reinforced. For the control group, this was accomplished through review of their homework assignments. Further reinforcement of the lesson was provided by means of the teacher's lecture and several examples given for guided practice. The experimental group also reviewed their homework assignments; however, reinforcement was provided by means of algebra tile manipulative activities and the accompanying activity sheets. The activity sheets contain five problems and each student completed two sheets. 3x - [ ] = [ ] when x = [ ], is a sample of the types of activities given to the students. They were required to replace [ ] with an algebra tile numbered zero through nine in order to form a true algebraic statement. Closure to the lesson was the same for both groups. This was accomplished by having the students summarize the lesson and key points in writing.

It should be noted that a test was given to evaluate the progress of the students after this lesson. This was given to fulfill school district requirements and was not used to assess achievement in this experiment.

The topic of the fourth lesson introduced to both groups was parentheses. There were two objectives as follows:

1) students would be able to evaluate numerical expressions with parentheses;

2) students would be able to evaluate algebraic expressions with parentheses given the values of all variables.

It was explained to the students that there are situations in which the order of operations may need to be altered. The use of parentheses will accomplish this. Students were given notes, key terms, examples for guided practice, and homework assignment to provide independent practice.

The following day both groups reviewed the homework assignments after which reinforcement of the lesson was provided. For the control group, this was accomplished by having the students copy the teacher's work as the teacher did selected problems on the chalkboard. For the experimental group, reinforcement was by means of a manipulative activity. Algebra tiles and the accompanying activity sheets were utilized. Each sheet contained five problems such as $(3 + [\ ]) \div [\ ] - 2 = 2$. Students were to replace [ ] with an algebra tile numbered zero through nine to form a true equation. To provide closure, both groups completed Lesson Masters 4-4 and 4-5. These are worksheets that are provided by the publisher of the textbook and are part of the teacher resource kit.

The topic of the fifth lesson was formulas. There were two objectives as follows:

1) students would be able calculate the area of any rectangle using the formula A = LW; and

2) students would be able to calcuate the area of a special region using the formula $A = S^2 - s^2$ (S is the area of large square and s is the area of a smaller square inside the larger square).

The special region is defined as the area inside the larger square, but outside the smaller square. This region was described to the students as a picture frame. The lesson was introduced to both groups by explaining key terms and concepts. The teacher proceeded to give examples and the students copied the work into their notes. The control group continued in the process for the remainder of the class time and then a homework assignment was given to provide independent practice. In the experimental group, each student was given a Geo-board and two rubber-bands. The students then formed rectangles with the rubber-bands and counted the square spaces enclosed by the rectangle. It was then explained and dimonstrated to the students how the formula A = LW will give the same result. The students contiuned to form two more rectangles, calculate the areas using A = LW, and then verified the results by counting the square spaces enclosed by the rectangles. Then students form a three by three square inside of a five by five square using the Geo-boards and two rubber-bands. Students were then asked to count the number of square spaces in between the two squares. It was then explained and demonstrated to the students how the formula $A = S^2 - s^2$ will give the same result. The students contiuned to form two more similar regions, calculate the areas using $A = S^2 - s^2$, and then verified the results by counting the spaces enclosed by the two squares. A homework assignment was given to provide independent practice.

The following day, both groups reviewed the homework assignments. The review of the homework assignment served as part of the reinforcement process for the control group. The students indicated which homework questions were difficult for them, and the teacher gave the correct solutions. The review of the homewok assignment served as part of the reinforcement process for the experimental group as well. However, the students in the experimental group were given Geo-boards and they were able to work on the problems which gave them difficulty on the Geo-boards. The teacher provided correctives and feedback if the students requested it, or if the teacher observed that a particular student was having difficulty. The lesson was then extended to include other types of formulas such as areas of other geometric shapes, distance problems, and interest problems. Both groups completed Lesson Master 4-6 which provided closure.

A lesson on grouping symbols was taught to both groups. Grouping symbols were defined as parentheses, brackets, and fraction bars. There were four objectives as follows:

1) students would know the correct order of operations;
2) students would be able to apply them in evaluating numerical expressions properly;
3) students would be able to evaluate numerical expressions with grouping symbols;
4) students would be able to evaluate algebraic expressions with grouping symbols given the values of all variables.

Students were given notes, key terms, examples for guided practice, and a homework assignment to provide independent practice.

The next day, the homework assignment was reviewed for both groups. The students indicated which problems gave them difficulty and the teacher showed the correct solutions on the chalkboard. The researcher determined not to use manipulatives during this lesson. Since this lesson on grouping symbols is an extension of the lesson on parentheses, using manipulatives would be redundant and counterproductive (Suydam, 1984). Therefore, this lesson was reinforced to both groups using Lesson Master 4-7.

It should be noted that a test was given to evaluate the progress of the students after this lesson. This was given to fulfill school district requirements and was not used to assess achievement in this experiment.

The next lesson was on the concept of open sentences. As a result of this lesson, students were able to solve simple equations using trail and error, or guess and check techniques. This lesson was introduced to both groups by having the students find two numbers whose product is 473,704. One of the missing numbers was either 56 or 65. The other was a four digit number comprised of the digits four, five, eight and nine. The students attempted to find the solution by employing a variety of techniques. The teacher used this problem to introduce two methods of solving equations. The control group copied notes from the teacher's lecture and were given Lesson Master 4-8 for guided practice. The experimental group used geo-boards to form all the possible rectangles with an area of 36 square units. They were then able to use this information to solve the equation 36 = 9w. They continued to solve similar problems. Next, algebra tiles were used to find the solution to 25 ÷ [ ] = 6.25 and 100 - [ ] = 53. To provide closure, the teacher summerized the three techniques that were used by both groups to solve equations.

The topic of the final lesson introduced to both groups was inequalities. There were three objectives as follows:

1) students would be able to choose the correct solutions to an inequality;

2) students would be able to graph the solutions to any inequality of the form $x < a$ and similar inequalities and identify such graphs;

3) students would be able to graph the solutions to any inequality of the form $a < x < b$ and similar inequalities and identify such graphs.

Teacher began by asking the students to list all of the numbers less then five. Most students quickly listed { 0, 1, 2, 3, 4 }. The teacher then reminded the students of decimals and negative numbers. The inequality, $x < 5$, was then introduced to the students as a way to account for all the numbers less then five. Students were given notes, key terms, examples for guided practice, and a homework assignment to provide independent practice.

The following day, both groups reviewed the homework assignments. Reinforcement of the lesson was provided after the homework was reviewed. For the control group, this was accomplished by having the students copy the teacher's work as the teacher did selected problems on the chalkboard. For the experimental group reinforcement was by means of a manipulative activity using algebra tiles and the accompanying activity sheets. Each sheet contained five problems like (3 + [ ]) ÷ [ ] - 2 > [ ]. Students were to replace [ ] with algebra tiles numbered zero through nine to form true inequalities. To provide closure, both groups completed Lesson Master 4-9.

Post-assessment

Mathematics Anxiety. MARS-A was readministered to assess mathematics anxiety among the sample of the experimental group. The results were analyzed to determine if there were any significant changes in mathematics anxiety among the two groups.

Mathematics Achievement. A test was used to measure the achievement of the samples in both the control and experimental groups. The specific instrument used to assess achievement was selected from the Tests and Quizzes booklet which is part of the teacher resource kit. This measure was supplemented by teacher-generated questions.

Summary of Procedures

To summarize the experiment, forty-three students participated in the experiment. Twenty-three formed the control group, and twentyformed the experimental group. Participants in each group were assessed to determine the level of mathematics achievement and anxiety. A five week experiment began covering nine lessons. In eight of those lessons, the experimental group used manipulatives to reinforce the concept after it was introduced. The control group had the lesson reinforced for them by means of teacher-oriented lessons. At the conclusion of the experiment, both groups were again assessed to determine if there were significant changes in mathematics achievement and anxiety.

CHAPTER 4

Results

Introduction

Student achievement in the State of New Jersey is measured each year by the High School Proficiency Test (HSPT). Students who perform poorly on the HSPT are in jeopardy of not obtaining a high school diploma. Research has shown that students with high mathematics anxiety tend to score lower on mathematics achievement tests (Clute, 1984). Greenwood (1984) asserts that teacher methodology can lead to mathematics anxiety. The objective of this experiment was to study the changes in mathematics anxiety and achievement if manipulatives were incorporated into teacher methodology. This chapter gives, in detail, the results of all tests and measures used in this experiment.

Results

To pre-assess mathematics anxiety, MARS-A was administered to the experimental group. When the experiment concluded, MARS-A was readministered for the purpose of assessing any significant changes in mathemaics anxiety within the experimental group. Because this attituded measure was used only with in the experimental group, dependent t test procedures were used. The resulting t value was

-1.09 with nineteen degrees of freedom. Table One shows that the pre-assessment mean of 197 is lower then the post-assessment mean of 215.9.

Table 1

Results from MARS-A

	N	Mean	S. D.	Error
Pretest	20	197	39.7	8.9
Posttest	20	215.9	66.8	15

$t = -1.09$
D. F. 19

A teacher-produced pretest was administered to the control group and the experimental group. The results are presented in Table Two. The mean for the experimental group ($n = 20$) was 50.4 and the mean of the control group ($n = 23$) was 43.5. The resulting t value was 1.05 with forty-one degrees of freedom.

Table 2

Results from pretest for achievement

	N	Mean	S. D.	Error
experimental	20	50.4	18.8	4.2
control	23	43.5	24.2	5

t = 1.05
D. F. 41

At the conclusion of the experiment, a teacher-produced posttest was administered to the control group and the experimental group for the purpose of assessing changes in mathematical achievement after manipulatives were incorporated into teacher methodology. The results are shown in Table Three. The mean for the the control group (n = 23) was 50.8, which was a gain of 7.3 points when compared to the pretest. The mean for the experimental group (n = 20) was sixty-two, which was a gain of 11.6 when compared to the prettest. The resulting t value was 1.81 with forty-one degrees of freedom.

Table 3

Results from the posttest for achievement

	N	Mean	S. D.	Error
experimental	20	62	12.4	2.8
control	23	50.8	26.5	5.5

t = 1.81
D. F. 41

CHAPTER 5

Summary of Findings, Conclusions and Recommendations

Introduction

Student achievement in the State of New Jersey is measured each year by the High School Proficiency Test (HSPT). Students who perform poorly on the HSPT are in jeopardy of not obtaining a high school diploma. Research has shown that students with high mathematics anxiety tend to score lower on mathematics achievement tests (Clute, 1984). Greenwood (1984) asserts that teacher methodology can lead to mathematics anxiety. The objective of this experiment was to study the changes in mathematics anxiety and achievement if manipulatives are incorporated into teacher methodology. This chapter will summarize the findings of the three forms of assessment which were used during this experiment.

Summary of Findings

MARS-A was administered twice, once as a pretest and again as a posttest. The mean of the pretest was 197 and the posttest mean was 215.9, which was an increase of 18.9.

A pretest was adminstered to assess levels of achievement before the experiment began. This achievement measure was given to both groups and covered a unit on measurement. This was discussed fully in Chapter Three. The mean of the experimental group was 50.4, and the mean of the control group was 43.5. Independent t test showed that, with alpha = 0.05, there was not a significant difference between the control group and the experimental group.

The experiment began as described in Chapter Three. At the end of the experiment, a posttest was given to assess changes in achievement and to determine if the null hypothesis should be accepted or rejected.

The posttest was described fully in Chapter Three. The experimental group had a mean of sixty-two, which was an increase of 11.6 points. The control group had a mean of 50.8, which was an increase of 7.3 points.

Conclusions

Mathematical Anxiety. A comparison of the means was not sufficient to form a conclusion because the difference in means could have been attributed to statisical error. Therefore, a dependent t test was performed to determine if the null hypothesis should be accepted or rejected. The resulting t value was -1.09 with nineteen degrees of freedom and alpha = 0.05. If the null hypothesis were to be rejected, the t value would have to be greater then 2.093, since this was not the case, the null hypothesis -- there will be no significant change in mathematical anxiety in the experimental group -- was accepted.

Posttest for Achievement. A comparison of the means was not sufficient to form a conclusion because the difference could have been attributed to statisical error. Therefore, an independent t test was performed and the resulting t was 1.81 with forty-one degrees of freedom. If the null hypothesis -- there will be no significant difference in mathematical achievement between the control group and the experimental group -- were to be rejected, with alpha = 0.05, then t would have to be greater then 2.021. Since this was not the case, the null hypothesis was accepted.

Therefore, in conclusion, there will not be a significant difference in mathematical anxiety nor mathematics achievement if a teacher uses manipulatives to reinforce a lesson.

The researcher believes that there were two particular extraneous variables which affected the results of the experiment. One such variable was apathy. The researcher observed that on both administrations of MARS-A, there were students who finished the ninety-eight questions very quickly, without giving much thought, if any, to their responses. In an informal interview with some of these students, they expressed apathy and disinterest. The second of these variables was attendance. There were eight students who transferred between groups or either in or out of classes during this experiment, and others had extremely high absenteeism. In the experimental group, the average student missed eight days of the twenty-five day experiment, or 32 % of the experiment. Days missed ranged from one day absent to twenty-three days absent. The control was very similar with regards to attendance.

Recommendations

If this experiment were to be duplicated, the researcher recommends that a larger sample size be used, and that the experiment be conducted more than five weeks. In designing future experiments, the researcher recommends that The Solomon Four-Group Design of True Experimentation is used (Best, 1993). The researcher believes that this will yield better results than the Equivalent Materials, Pretest, Posttest Design of Quasi-Experimentation which was used in this study. The extraneous variables of apathy and poor attendance may be controlled if the experiment were conducted earlier in the school year. These variables may be of interest to other researchers and can be controlled by building then into future studies as independent variables.

Appendix

Results from MARS-A to assess anxiety with in the experimental group

Pretest	Posttest
252	292
258	234
159	151
240	324
136	115
148	171
183	182
243	264
232	250
178	182
227	148
207	275
226	285
163	136
243	192
185	227
173	326
160	212
179	245
148	107

Results from the mathematical tests to assess achievement with in the experimental group

Pretest	Posttest
0	50
63	51
50	54
65	87
50	60
50	60
50	50
50	57
69	66
69	78
50	50
50	50
50	72
63	63
60	50
50	50
50	63
69	84
0	81
50	63

Results from the mathematical tests to assess achievement with in the control group

Pretest	Posttest
50	50
51	0
50	51
66	0
0	78
60	87
50	75
0	51
54	54
66	50
0	0
50	50
50	0
69	72
0	51
63	75
57	50
0	54
50	50
50	75
57	63
51	76

MATHEMATICS ANXIETY RATING SCALE-A (MARS-A)

(ADOLESCENT FORM)

INFORMATION FOR USERS

The Mathematics Anxiety Rating Scale-A (MARS-A) is a 98 item self rating scale which may be administered either individually or to groups. The procedure is as follows:

Each item on the scale represents a situation which may arouse anxiety within a subject. The pupil is to decide on the degree of anxiety aroused, using the dimensions of "Not at all", "A little", "A fair amount", "Much", or "Very much".

Once the pupil has decided the level of anxiety associated with a specific test item, he makes a check (✓) in the box next to the item reflecting his or her decision.

Directions are included for the students to read on each test blank. Students are encouraged to work as rapidly as possible, but with accuracy. They are asked to describe their anxieties as they currently exist.

To score, the examiner should begin by writing the values at the top of each of the respective columns: "1" above "Not at all", through "5" above "Very much". Next, the examiner should count the number of checks in each column and multiply each total by the corresponding weight (1 to 5) for that column. The product for each column in then recorded at the bottom of the page. This procedure is repeated for each page of the scale. Finally, the sum of all the products on all the pages provides the Total Score for the test.

If the MARS-A is used as the basis for forming a desensitization therapy anxiety hierarchy, the items are inspected to identify those which arouse differing levels of anxiety. Thus, if only a five item hierarchy is desired, the therapist may select one item from the "Not at all" category checked by the client, one from the "A little", one from the "A fair amount", one from the "Much", and one from the "Very much" categories. This provides a series of situations ranked from low to high which may be used as the anxiety hierarchy for that client.

<u>Normative Data</u>

Several normative tables are provided for users. Each table reports the percentile equivalents for MARS-A raw scores. First, select the appropriate table. If you are examining students from a class and wish to compare the class results against the norms for 7th, 8th, 9th, 10th, 11th or 12th graders, then refer to the appropriate columns in Tables I or II. Similarly, if you are interested in comparing a single student's MARS-A raw score against those of other students in the same grade level, then refer to the appropriate columns in either Table I or II. For example, if an individual 9th grade student received a MARS-A score of 200, and you are interested in what that means in terms of 9th graders, then Table I shows that this score falls at about the 60th percentile, therefore the student is expressing a modest amount of mathematics anxiety.

If you are interested in comparing a class or an individual student's MARS-A raw score against norms for boys or norms for girls, then Table III is used. For example, if you have a high school boy who scores 150 on the MARS-A, then Table III shows that this score for male high school subjects falls at about the 20th percentile, thus indicating low mathematics anxiety.

Reliability

Reliabilities were calculated from differing formulae to determine the stability of test scores. The sample was composed of 1,313 Junior and Senior High School students, taken from two states. By the Spearman-Brown formula, the reliability coefficient was .90; by the Guttman Split-Half method, the reliability coefficient was .89. As an index of internal consistence, a coefficient alpha was computed and found to be .96. In effect this shows that the test items appear to be highly stable and reliable, and that the test is dominated by a homogeneous factor, presumably mathematics anxiety.

Use of the MARS-A

The MARS-A can be used to screen individual students in order to plan their placements in special mathematics courses, provide counseling, or provide for intervention through programs such as desensitization for anxiety. Typically, a value above the 75% level would indicate the student is eligible for attention of this type, however a school may wish to develop its own norms or cut-off scores.

The MARS-A can also be used as a measure for evaluating programs. It could be administered prior to a new counseling program or curriculum change, and readministered later to determine the effects of the programs.

Finally, the MARS-A may be used as a part of direct research on mathematics anxiety. For example, it would be a useful measure in studies which examine the role of curriculum content, parental characteristics, extra-curricular activities, etc., in influencing mathematics anxiety.

TABLE I

Normative Data for High School Students

Percentile	10th Grade	11th Grade	12th Grade
5%	129	110	120
10	137	131	127
20	150	156	135
30	163	166	144
40	175	173	153
50	189	188	176
60	203	200	192
75	238	224	217
80	248	234	224
95	305	277	278
	N = 188	N = 78	N = 57

TABLE II

Normative Data for Junior High School Students

Percentile	7th Grade	8th Grade	9th Grade
5%	127	121	119
10	140	129	132
20	163	145	147
30	182	157	161
40	198	170	174
50	214	188	188
60	228	207	201
75	259	235	229
80	269	246	242
95	330	310	291
	N = 316	N = 363	N = 269

TABLE III

Normative Data for Junior and Senior High School Students by Sex

	Junior High		High School	
Percentile	Boys	Girls	Boys	Girls
5%	119	126	119	134
10	131	137	132	137
20	147	152	147	155
30	160	168	162	168
40	176	184	174	179
50	193	200	188	192
60	211	214	200	202
75	241	248	230	232
80	252	260	240	246
95	321	311	290	306
	N = 477	N = 486	N = 144	N = 127

NAME ________________________________

Chapter 3 Test, Form A

50

You will need a ruler marked in inches and centimeters, a protractor, and your calculator.

1. In what country was the system of measurement now called the U.S. system developed? 1. ________
2. Which system of measurement is used in most of the world today? 2. ________
3. What unit of measure still in use today was invented by the Babylonians? 3. ________
4. What is the meaning of the prefix *centi-*? 4. ________

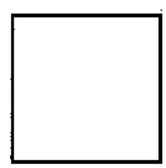
In 5–7, choose the most appropriate unit of measure.

5. a U.S. measure for the amount of water in a bathtub 5. ________
6. a U.S. measure for the weight of a mailing envelope 6. ________
7. a metric measure for the area of a basketball court 7. ________

In 8–11, convert to the given unit.

8. 1 milliliter = __?__ liters 8. ________
9. __?__ grams = 1 kilogram 9. ________
10. __?__ pints = 1 quart 10. ________
11. 1 yard = __?__ inches 11. ________

In 12–14, refer to the square at the right.



12. Measure one side to the nearest $\frac{1}{4}$ inch. 12. ________
13. Measure one side to the nearest tenth of a centimeter. 13. ________
14. Find the area in square inches. 14. ________

In 15–18, write ≈, =, <, or > to compare the two given measures.

15. 1 inch, 2.54 centimeters 15. ________
16. 1.5 meters, 40 inches 16. ________
17. 1 kilogram, 2.2 pounds 17. ________
18. 9 quarts, 1 gallon 18. ________

Continued

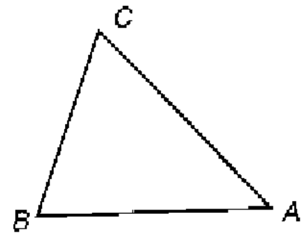
NAME ______________________

Chapter 3 Test, Form A

19. ______________

20. ______________

In 19 and 20, refer to the figure at the right.



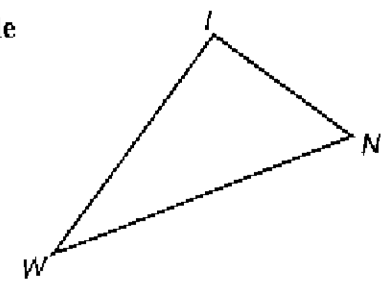
19. Find m $\angle ABC$.

20. Is $\angle ABC$ acute or obtuse?

21. In the space at the right, draw an angle of measure 148°.

21.

In 22 and 23, refer to the triangle at the right.



22. Which angles seem to be right angles?

23. What term describes the relationship between side WI and side NI?

24. An obtuse angle has measure between what two degrees?

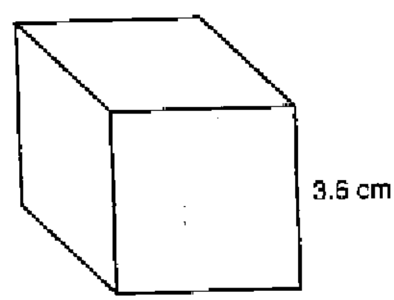
25. Find the volume of the cube pictured.

22. ______________

23. ______________

24. ______________

25. ______________



26. How many feet are in a half mile?

27. How many milliliters are in 2.3 liters?

28. How many square feet are in a square yard?

29. Don bought $\frac{3}{4}$ pound of mozarella cheese. His pizza recipe calls for 8 ounces of cheese. Does he have enough cheese?

26. ______________

27. ______________

28. ______________

29. ______________

Continued

NAME ______________________________

Chapter 3 Test, Form A

30. The Tour de France bicycle race is about 4020 kilometers. To the nearest mile, how many miles is this? — 30. __________

31. The average teenage boy needs 100 g of protein in a day. To the nearest tenth of an ounce, what is the requirement in ounces? — 31. __________

32. In the space at the right, draw an accurate square inch. — 32.

In 33, show all your work.

33. How many degrees does the minute hand of a clock move in a day? — 33. __________

34. Use the Estimation Principle to estimate $\frac{7}{18} + \frac{11}{20}$ to the nearest integer. — 34. __________

35. A garden is in the shape of a square that measures 50 ft on each side. What is the area of the garden? — 35. __________

Now check all your work carefully.

CHAPTER 3 TEST FORM A
ANSWERS.

*UNLESS OTHERWISE STATED,
USE "E" FOR **"ANSWER NOT GIVEN"**

#1 A) ENGLAND	B) FRANCE	C) CANADA	D) U.S.A
#2 A) METER	B) POUNDS	C) METRIC	D) CUSTOMARY
#3 A) BABIES	B) INCHES	C) GRAMS	D) DEGREE
#4 A) HUNDRED	B) HUNDREDTHS	C) MILLIONTHS	D) WORMS
#5 A) LITER	B) MILLILITERS	C) CENTILITER	D) GALLONS
#6 A) GRAMS	B) MILLIGRAMS	C) CENTILITER	D) TONS
#7 A) METERS	B) CUBIC METERS	C) SQUARE METERS	D) FEET
#8 A) 1	B) 10	C) 100	D) 1000
#9 A) 1	B) 10	C) 100	D) 1000
#10 A) 16	B) 2	C) 4	D) .01
#11 A) 36	B) 12	C) 3	D) 1760
#12 A) 3/16	B) 1/8	C) 1.4	D) 14
#13 A) ten	B) one	C) two	D) twenty
#14 A) 9/16	B) 1/8	C) 1	D) 1.25
#15 A) $\approx$	B) $=$	C) $<$	D) $>$
#16 A) $\approx$	B) $=$	C) $<$	D) $>$
#17 A) $\approx$	B) $=$	C) $<$	D) $>$
#18 A) $\approx$	B) $=$	C) $<$	D) $>$
#19 A) 90	B) 70	C) 110	D) 45

#20	A) acute	B) obtuse		

#21 **DO THIS ON PAGE ONE OF YOUR ANSWER FOLDER**

#22	A) W	B) I	C) N	D) ALL
#23	A) RIGHT	B) LEFT	C) ACUTE	D) PERPENDICULAR
#24	A) 0 &90	B) 0 &180	C) 90 & 180	D) ANY NEGATIVE
#25	A) 46.656	B) 12.96	C) 14.4	D) 28.8
#26	A) 1320	B) 5280	C) 10560	D) 2640
#27	A) 23	B) .023	C) .0023	D) 230
#28	A) 3	B) 9	C) 27	D) 36
#29	A) YES	B) NO	C) NOT ENOUGH INFORMATION	
#30	A) 251.25	B) 6432	C) 2492	D) 1000
#31	A) 3.5	B) 56	C) 220	D) .022

#32 **DO THIS ON PAGE ONE OF YOUR ANSWER FOLDER**

#33	A) 360	B) 180	C) 8640	D) 4320
#34	A) 1/2	B) 0	C) 1	D) 90
#35	A) 100	B) 200	C) 250	D) 2500

NAME ____________________

Chapter 4 Test, Form A

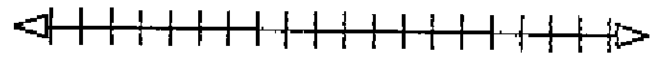
In the formula $A = lw$, the area A is expressed in terms of **1.** _?_ and 2. _?_.

1. ____________

2. ____________

3. *Graph all solutions to* $a \geq 5$.

3.



4. *Multiple choice* Most of the symbols for arithmetic operations are
(a) about 200 years old. (b) about 1000 years old.
(c) less than 500 years old. (d) less than 200 years old.

4. ____________

In 5–10, translate into algebra. Let *n* stand for the number.

5. the sum of the number and eight **5.** ____________

6. eight less than the number **6.** ____________

7. Eight is less than the number. **7.** ____________

8. twice the number, plus seven **8.** ____________

9. a number minus six, divided by three (Be careful.) **9.** ____________

10. half of the number, plus four **10.** ____________

In 11–18, evaluate each expression.

11. $12 + 8 - 5 + 3$ **11.** ____________

12. $10 + 5 \cdot 8 - 4 \div 2$ **12.** ____________

13. $100 - 8(4 + 2)$ **13.** ____________

14. $\dfrac{6(10 + 2)^2}{36}$ **14.** ____________

15. $5 + 4a$, if $a = 8$ **15.** ____________

16. $(x + y)(x - y)$, when $x = 10$, $y = 2$ **16.** ____________

17. $[x(y + z)]^2$, if $x = 3$, $y = 2$ and $z = 1$ **17.** ____________

18. $g + 8[g + 5(g + 1)]$, if $g = 1.5$ **18.** ____________

Continued

NAME ______________________________

Chapter 4 Test, Form A

19. Give two instances of this pattern:
$a(b - c) = ab - ac$

19. a. ____________

b. ____________

20. Use one variable to give the pattern for these instances.
One car has $1 \cdot 4$ tires.
Two cars have $2 \cdot 4$ tires.
Three cars have $3 \cdot 4$ tires.

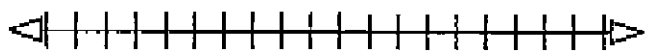
20. ____________

21. The formula for finding a baseball player's batting average is $\frac{H}{AB}$, where H stands for *hits* and AB for *at bats*. This number is rounded to the nearest thousandth. In 1984, San Diego outfielder Tony Gwynne had the highest batting average of any major league hitter. He had 213 hits in 606 at bats. What was his average?

21. ____________

22. Graph all solutions to $4.5 \geq t > 0$.

22.



23. Solve these open sentences.

a. $x + 5 = 8$

b. $10 - c = 2$

c. $2w = 7$

d. $t \div 4 = 3$

e. $2z + 1 = 5$

23. a. $x =$ ____________

b. $c =$ ____________

c. $w =$ ____________

d. $t =$ ____________

e. $z =$ ____________

24. *Multiple choice* Which of these is a solution of $a < -3$?
(a) 1 **(b)** -1 **(c)** -4 **(d)** 2

24. ____________

25. Three instances of a pattern are given. Describe the general pattern using one variable. $6 \cdot 1 = 6$ $\frac{1}{10} \cdot 1 = \frac{1}{10}$ $\pi \cdot 1 = \pi$

25. ____________

26. Translate into mathematical symbols: the product of seven and six, decreased by five.

26. ____________

Now check all your work carefully.

CHAPTER 4 TEST FORM A
ANSWERS.

*UNLESS OTHERWISE STATED,
USE "E" FOR **"ANSWER NOT GIVEN"**

#1 A) Length	B) Leg	C) Base	D) Square inches
#2 A) Height	B) waist	C) Width	D) Inches

#3 **Show the answer on page 1 of your answer folder.**

#4 The choices are on the test.

#5 A) n+8	B) nx8	C) 8-n	D) n<8
#6 A) 8-n	B) n-8	C) n<8	D) n>8
#7 A) 8-n	B) n-8	C) n<8	D) n>8
#8 A) 2n+7	B) 2(n+7)	C) 2x7+n	D) 7/n+2
#9 A) n-6÷3	B) n-(6÷3)	C) (n-6)÷3	D) n<2
#10 A) 1/2n=4	B) (n+4)/2	C) $^{1}/_{2}$(n)+4	D) 0.5(n+4)
#11 A) 12	B) 18	C) 3	D) 1760
#12 A) 58	B) 118	C) 48	D) 52
#13 A) 69,696	B) 18	C) 48	D) 52
#14 A) 24	B) 1/6	C) 72	D) 12
#15 A) 53	B) 9a	C) 8a	D) 13a
#16 A) 12	B) 20	C) 96	D) 0
#17 A) 81	B) 321	C) 12	D) 12x
#18 A) 113.5	B) 100	C) 40g	D) 1.5

#19 **Show the answer on page 1 of your answer folder.**

#20 A) Four cars have $4 \cdot 4$ tires
C) N cars have $4 \cdot 4$ tires

B) Four cars have 16 tires
D) N cars have $4 \cdot N$ tires

#21 A) 2.84 B) .606 C) .351 D) .213

#22 **Show the answer on page 1 of your answer folder.**

#23 **Show the answer on page 1 of your answer folder.**

#24 The choices are on the test

#25 A) $n/n=1$ B) $a/b=c$ C) $n \cdot 1=n$ D) 5 times 1 = 5

#26 A) 37 B) 7x6-5 C) 6(7-5) D) 7x(6-5)

OPEN-ENDED QUESTIONS

DO NOT WRITE ON THIS TEST

In this section of the chapter test, each question is worth 3 points. Showing your work is very important. A correct answer without work is only worth 1 point. Be sure to completely show work, tables and/or lists for all three problems on the answer folder of the scan-tron sheet. Written explainations must also accompany each answer.

1. Skunks in the Malaga Zoo are kept together in cages in pairs. The first cage has 2 skunks. The second cage has 4 skunks, and the third cage has 6 skunks. How many skunks are in the tenth, twenty-first and one-hundredth cage? Describe the pattern with a variable, and explain how you arrived at your answers.

2. Consider the pattern $N^2 < N$, give an example when this is true and give an example when this pattern is false.

3. Anyone can rewrite the numbers from 1 to 10 by using four fours. For example, $4 + 4/4 - 4 = 1$. Use four fours and any combination of operations to develop 3 expressions that are equal to 3 different numbers.

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