I.

The Problem, Hypothesis, and Definition of Terms

Teachers know that students learn in different ways. In order for instruction to reach all students, teaching methods must relate to each child’s own learning preference style. Howard Gardner’s theory of multiple intelligences is important to teachers who are looking to meet these diverse needs.

What does multiple-intelligence theory have to do with teaching mathematics? According to Willis and Johnson (2001) it results in a deeper and richer understanding of mathematical concepts through multiple representations; enables all students to learn mathematics successfully and enjoyably; allows for a variety of entry points into mathematical content; and focuses on students’ unique strengths.

Knowing that no one method of learning is appropriate for all children, teachers should have a variety of mathematics strategies from which to choose, therefore appealing to all learning preference styles. Using a variety of materials allows students to gain experience for understanding and using mathematics. For these reasons, school systems encourage their teachers to search for new and better ways to help children learn.

Many ways to meet these needs are offered by NCTM (2000). The set of standards for pre-kindergarten through grade two (2) suggests “schools should furnish a variety of materials so children can connect learning to what they already know. Recommended materials are blocks and clay, playing games and doing puzzles, listening to stories, and engaging in dramatic play, music, and art” (p. 75).
To learn mathematics, students need to internalize ideas using methods that are meaningful to them. They need the abstract brought to the concrete level for understanding. The use of math manipulatives can be one method to help students accomplish this. Students become active participants of their own learning and formation of idea concepts. Manipulatives can be used to teach to different modalities at the same time, thus reaching a larger percentage of students during instruction.

The purpose of this study will be to investigate the positive gains in mathematics achievement of first grade students who use a multi-sensory approach to addition.

Hypothesis: First grade students taught addition through a multi-sensory approach will show higher mathematical achievement than those who are not taught through a multi-sensory approach.
Definitions of Key Terms

Control group - students not exposed to a special instructional technique

Dependent variable - mathematics achievement

Independent variable - type of instructional method used (TouchMath or traditional)

Inclusion classroom - a general elementary classroom that includes students with learning disabilities

Manipulatives - objects that appeal to the senses and can be physically or mentally moved or touched as in blocks, computer images, or Touchpoints

Mathematics achievement - measured by comparing the gain from pretest to posttest scores

Multi-sensory - appealing to the visual, auditory, and tactile/kinesthetic senses

Research week - a five (5) day school week starting on Monday and ending on Friday

TouchMath - a multi-sensory approach that makes a connection between the concrete and abstract of number values

Touchpoints – each digit from one (1) through nine (9) has Touchpoints corresponding to the digit’s quantity. Numerals one (1) through five (5) use single Touchpoints, or dots. Numerals six (6) through nine (9) use double Touchpoints symbolized by a dot inside of a circle. These are also referred to as manipulatives.

Traditional approach - a method of instruction based on memorization, drill, practice, and worksheets

Treatment group - students exposed to a special instructional method that the researcher hypothesizes will change achievement.
II. Literature Review

Rust (1999), in her eight (8) week long study, attempted to determine which teaching method, manipulatives or the standard curriculum, best allowed students to learn first grade math concepts. Test scores showed that students learned more through book teaching than math manipulatives. The researcher was doing the actual procedure rather than supervising. Her involvement could have led to bias. The study was limited to one (1) first grade class. A larger number of subjects would have been a more representative sample of the overall population. The researcher noted that students seemed to enjoy the hands-on learning more than the bookwork. However, enjoyment was not directly evaluated.

Concrete materials do not automatically carry mathematical meaning for students. It’s the idea you want students to understand in the way it is presented. (Thompson, 1994) Using concrete materials does not always mean the idea is fully grasped. Clements (1996) believes that students need concrete materials to build meaning initially, but they must reflect on their actions with manipulatives to do so. Children need to use manipulatives to actively engage their thinking. If there is no concept understanding, manipulative practice will be ineffective. “Children need to have a balance between manipulative practice and concept formation” (Li, 1999).

Good lessons using manipulatives don’t just happen. They are the product of much advance thought and preparation. Some of the work happens years or months in advance as teachers receive training on how to incorporate manipulatives into their instruction; other
advance work happens the day or night before a lesson is taught. (Stein, Bovalino & Smith, 2001)

The National Council of Teachers of Mathematics in their 2000 Principles and Standards states:

Concrete models can help students represent numbers and develop number sense; they can also help bring meaning to students’ use of written symbols and can be useful in building place-value concept. But using materials, especially in a rote manner, does not ensure understanding. (NCTM, 2000, p. 80)

In an effort to de-abstract mathematics, the use of manipulatives brings it to the concrete level. The Standards recommends a list of manipulatives for kindergarten through grade eight (8), but no list is recommended for grades nine (9) through twelve (12). Students in these grades also need to see ideas represented at the concrete level. “Experiential education is based on the idea that active involvement enhances students’ learning” (Hartshorn & Boren, 1990).

Computer instantiated manipulatives (CIM) may be an alternative to concrete manipulatives to solve open-ended math problems, particularly with computers in most schools and classrooms. Takahashi (2000) examined eighteen (18) fourth grade children as they sought to find all eighteen (18) ways to cover an equilateral triangle using three (3) blue pattern blocks and three (3) green pattern blocks. Nine (9) children worked alone on computers; nine (9) children worked in groups of three (3) with manipulatives to solve this problem. The study found that the children working on the computers found more solutions and spent more time on task before wanting to stop. Working on the computer facilitated better learning opportunities because it printed out each solution the students found; the manipulative groups needed to color a sample triangle for each solution they found. The manipulative groups also had to take apart
each solution to reuse the pattern blocks. While this study showed that computers might be a promising tool equivalent to concrete manipulatives, it did have a limitation. This study applied to small groups only. A future study could involve looking into classroom situations.

Virtual manipulatives are visual representations for computer programs. Dynamic visual representation can be manipulated in the same ways as concrete manipulatives. This enables the user to make meaning and see relationships as a result of one’s own actions. For students in grades four (4) through eight (8), the use of virtual manipulatives may remove the connotation of “playing with blocks.” Older students may view the use of virtual manipulatives as more sophisticated than using manipulatives in their concrete form. (Moyer, Bolyard & Spikell, 2002)

The National Council of Teachers of Mathematics agrees with the use of technology in the classroom, and likens it to the use of concrete materials.

Technology can help students develop number sense, and it may be especially helpful for those with special needs. For example, students who may be uncomfortable interacting with groups or who may not be physically able to represent numbers and display corresponding symbols can use computer manipulatives. (NCTM, 2000, p. 80)

In a study comparing traditional instruction to computer-enhanced instruction to sixteen (16) first graders, Shults (2000) found no significant difference upon t-test comparison of the mean percentile scores. The control group’s mean score was higher than the treatment group’s mean score. This was attributed to student disinterest in the software in the latter part of the experiment.
Clements (1996) stated, “The definition for manipulatives may need to be expanded, especially with the use of computers in school.”

McCoy (1989) assessed the use of concrete materials in mathematics instruction. He also compared the perceptual preferences of elementary students who had been mathematics deficient with students whose math achievement was average or above average. He did his research at two (2) schools with twenty-four (24) teachers. His subjects, from grade levels three (3) through six (6), included eleven (11) students from a remedial group and eight (8) students from a regular education group. Through teacher questionnaires, he found that four per cent (4%) of the teachers never use manipulative materials, eighty-three per cent (83%) sometimes use them, and thirteen per cent (13%) often use them. This means most of the teachers use manipulatives sometimes, so they must be using the traditional visual and auditory instruction the other part of the time. Subjects took the Learning Style Inventory to determine which perceptual preference-learning mode they preferred. He found that the regular education subjects had a significantly stronger preference for auditory or visual while the remedial subjects preferred a kinesthetic mode significantly more. This leaves a gap between the perceptual preference of the remedial subjects and the usual mode of teacher instruction. Although his study yielded interesting results, it covers a large span of grades and is limited by the number of subjects, both teachers and students.

The belief that teachers need to include in each teaching presentation at least three (3) basic learning modalities (auditory, visual, and tactile), to meet the needs of most students, is a common thread among researchers. (Caudill, 1998; Gadt-Johnson, 2000; Willis, 2001)

Students require exposure to many different kinds of manipulatives. “They will construct a deeper understanding of fractions when they are presented in a variety of ways and are related
to everyday life. Students need to see fractions as part of a shape, part of a group of things, or part of a length” (Millsaps, 1998).

Baker & Beisel (2001) investigated the ways children understand the concept of average. Using a traditional approach with problem solving, a concrete approach with manipulatives, and a visual approach with computer-spread sheets, lessons on mean were taught to twenty-two (22) children in grades four (4) through six (6). Differences among pretest and posttests found some advantage in the use of visual instructional style.

In most classroom work, we teach to three (3) modalities: verbal, visual, and physical. These modalities have different capacities for memory storage; while the verbal modality is limited, the visual modality is nothing short of phenomenal. The visual modality seems capable of producing immediate comprehension almost effortlessly. Hence, the saying, *a picture is worth a thousand words.* (Jones 2000, p.74)

Chester (1991) found that third grade students who were presented geometry concepts with manipulatives scored significantly higher on the posttest than the group that was presented concepts using only drawings and diagrams. Her research was limited because it was only a two (2) week study of two (2) third grade classes.

When students are able to represent a problem or mathematical situation in a way that is meaningful to them, it becomes more accessible. Using representation—whether drawings, mental images, concrete materials, or equations—helps students organize their thinking and try various approaches that may lead to a clearer understanding and a solution. (Fennell & Rowan, 2001)
The use of manipulatives in teaching mathematics has become very prominent in the past decade. Through many studies, manipulatives have shown to be beneficial in mathematics. Students who use manipulatives in their mathematics classes usually outperform those who do not. The increase in performance is evident in all grade levels, ability levels, and topics. The use of manipulatives also increases scores on retention and problem solving tests. Finally, attitudes toward mathematics are improved when students are instructed with concrete materials by teachers knowledgeable about their use. (Clements & McMillen, 1996)

Piaget’s work has had a great impact on American education since the 1960’s. By observing his own two (2) children extensively, he found that they moved through three (3) developmental learning stages: the concrete or manipulative, the representational or transitional, and the abstract. Piaget seemed to be aware of the importance of manipulatives long before the word became established in the educational field.

Logical-mathematical knowledge can develop only if a child acts (mentally or physically) on objects. The child invents logical-mathematical knowledge; it is not inherent in objects but is constructed from the actions of the child on the objects. The objects serve merely as a medium for permitting the construction to occur. Logical-mathematical knowledge is constructed from exploratory actions on objects when the most important component is the child’s action, not the particular object(s). Number, length, and area concepts cannot be constructed only from hearing about them or reading about them. (Wadsworth, 1996, p. 149)
Constructivist teachers believe there are practical alternatives to drill and practice that combine the teaching of math facts with meaningful mental engagement. (Wakefield, 2001)

Scott (1993) examined the effects of a multi-sensory program called TouchMath with three (3) fourth grade students with mild disabilities. Her results show that it can be an effective tool in teaching addition and subtraction with and without regrouping. The subjects had success in maintaining and generalizing the TouchMath approach to other mathematical problems. The limitation of her study included a very small sample size of only three (3) participants.

Mather & Goldstein (2001) recommended using the TouchMath approach with children who have weakness in the processing block. They benefit from a multi-sensory approach to learning math facts. The visual, auditory, and motor skills of the symbolic blocks are used to aid memorization.

Hanrahan (2000) discussed research that had success teaching addition and subtraction to a small group of mildly to moderately intellectually disabled children using an adaptation of the TouchMath approach. The children liked this dot-notation approach because it allowed them to appear as if they were mentally computing as their non-disabled peers were doing. This approach offered these subjects a positive attitude toward computation when it allowed them to be like their peers.

Research has shown that there are three distinctive learning styles: auditory, visual, and tactile. Each student has his or her own unique learning preference style or way of processing and retaining information. When teachers use strategies for all learning styles, individual students are able to learn through their strongest modality.

Research has also shown that elementary school children learn best in a tactile/kinesthetic style. When students can manipulate and experience conceptual information through activities,
only then, will they learn and retain information more readily. Although this type of learning style is used throughout life, it becomes less dominant as the visual and auditory modalities develop.

This study supports recent research that proves a multi-sensory approach during instruction increases mathematics achievement.
III.
METHODOLOGY

Subjects

The subjects involved in this study were one hundred ten (110) first grade students from six (6) intact, self-contained classrooms. Two (2) of the six (6) classes involved in the study were inclusion classrooms. The classes were heterogeneously grouped with a well-balanced range of abilities. The students ranged between the ages of six (6) and seven (7) years old. They had completed a year of full day kindergarten. The six (6) classrooms involved in the study were established groups, organized for instructional purposes.

The control group (n = 52) was comprised of two (2) general elementary first grade classrooms and one (1) first grade inclusion classroom. The treatment group (n = 58) was comprised of two (2) general elementary first grade classrooms and one (1) first grade inclusion classroom.

Convenience sampling, a type of nonprobability sampling, was done using subjects who were accessible. The subjects were predominately Caucasian of low socioeconomic status (determined by the high number of children on free or reduced price lunch) attending a suburban primary school.

Confidentiality of data of individuals was established by reporting group results.

Design

The type of design used was quasi-experimental. Its purpose was to investigate the cause and effect between manipulated conditions and measured outcomes. Mathematics achievement was the dependent variable and the method of instruction was the independent variable. The
differences between the two groups were examined to see if the type of instructional approach had an effect on achievement. This study was conducted using the non-equivalent groups pretest-posttest design.

**Instrumentation**

The subjects were pretested and posttested using a teacher made test modeled after the Fact Test I that accompanied the TouchMath Addition Kit. (Bullock, 1991) The pretest consisted of forty-nine (49) addition facts whose sums ranged from two (2) through ten (10) (see Appendix A). The posttest was an alternate form of the pretest (see Appendix B). The posttest was valid because it aligned with the objectives from the Harcourt Brace (2000) series that were taught to both groups during the research week. The facts were printed in vertical form on the test. This was the same format presented during the unit of study. This test was also directly related to this research study. These were all indications of content validity.

This test was reliable because the test-retest method was stable. The only problem with the test-retest method was that some subjects possibly remembered what was on the pretest and learned from that.

A time limit of eight (8) minutes was permitted for completion of the pre and posttests, respectively. That allowed approximately ten (10) seconds per example.

**Procedure**

Prior to starting the one (1) week unit on sums to ten (10), both the control group and the treatment group were given the pretest. Both groups then completed Chapter Four (4) in the first grade edition of Harcourt Brace (2000) workbook on addition during the research week. Each daily mathematics lesson lasted approximately forty-five (45) minutes.
The teacher and the students in the control group used the chalkboard and chalk, drill, memorization, and worksheets, as the concept of addition was discussed, taught, and learned.

The teacher and students in the treatment group used the TouchMath approach and its materials as the concept of addition was discussed, taught, and learned. Materials consisted of a Touchpoint poster (see Appendix C) displayed in the classroom. The teacher and students referred it to frequently. Each student had a desktop guide with the location of the touchpoints on each numeral. Students and their teacher looked at the number and touchpoints (visual), counted the Touchpoints out loud (auditory), and simultaneously tapped the Touchpoints with their pencils (tactile). They practiced this each day of the research week for five (5) minutes to become familiar with the Touchpoints.

For Touchpoints and the order in which to count them see Appendix D.

For this research study, only the smaller addend bore the touchpoints. This was the second stage of the TouchMath approach. The first stage required Touchpoints on both addends. This researcher did not believe there was a need to start at the “count all” stage with these subjects because of the academic year of full day kindergarten completed. The subjects learned the addition statement (see Appendix E) to help them at this second stage. Subjects touched the larger number with their pencil point, said its name, and continued “counting on” the dots of the smaller number with their pencil point to obtain the sum. When the treatment group did their workbook pages, they were allowed to put the Touchpoints on the smaller number, or if not needed, visualized and tapped where the touchpoints were located from memory.

At the conclusion of the research week, all students were posttested using the aforementioned teacher made addition test to determine the hypothesis of this study: First grade
students taught addition through a multi-sensory approach will show higher mathematical achievement than those who are not taught through a multi-sensory approach.

The control group was taught the TouchMath approach after the study was completed, hence, receiving the equal advantage of having another strategy to use for addition.

**Threats to Validity**

Selection was the most serious internal threat to the non-equivalent groups pretest-posttest design because the groups differed in characteristics that could affect mathematics achievement (dependent variable). Examples of these include pretest scores, age, race, achievement aptitude, or socioeconomic status.

Another threat to internal validity includes history. This occurs during research and involves any students who may have been tutored at home or helped by an adult. It may also include any classroom interruptions unforeseen by the researcher such as a visitor, fire drill, or assembly during math time.

Pretesting effect can happen when achievement is measured over a short period of time as in this research study of one (1) week. The pretest may have provided the subjects with addition practice or familiarity of addition.

Diffusion of treatment could occur if the control group found out about a different way to do addition from the treatment group.

Threats to ecological external validity may have included students’ physical surroundings (i.e. where the classroom was located in relation to the gym or outdoor recess play area). Either of these areas could have been a distraction if it was noisy.

Absence, by any subject in either group, during the research week could have a negative effect on the posttest scores.
To minimize the extraneous confounding variables of fatigue and hunger, all mathematics classes were taught in the morning after snack time.

Limitations of this study include the brevity of time in which it was conducted and the exclusion of attendance data for the research week. Each subject who took the pretest also took the posttest.
IV.

FINDINGS, ANALYSIS, INTERPRETATION OF DATA

Findings were analyzed by comparing the means of the pretests and posttests of each group, and comparing the group’s differences.

The highest attainable score was forty-nine (49) points and the lowest attainable score was zero (0) points. For frequency distribution of scores for the control group and the treatment group see Appendix F and Appendix G, respectively. The means of the pretest and posttest for the control group and the treatment group were compared. Table 1 shows this comparison. (see Appendix H)

Table 1   Mean comparison of pretest/posttest scores

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pretest Mean</th>
<th>Posttest Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>34.54</td>
<td>40.46</td>
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<tr>
<td>Treatment</td>
<td>32.57</td>
<td>43.20</td>
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</table>
The difference between the means of the pretest and posttest for the control group showed a gain of 5.92 points (see Appendix I for individual class means within the control group). The difference between the means of the pretest and posttest for the treatment group showed a gain of 10.63 points (see Appendix J for individual class means within the treatment group) (see Table 2).

**Table 2  Difference between the means**

<table>
<thead>
<tr>
<th>Difference between the means</th>
<th>Control</th>
<th>Treatment</th>
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<tbody>
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<td>5.92</td>
<td>10.63</td>
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</table>

Significance in the difference between the means of each group was measured using a paired t-test procedure. In order to present a valid comparison of the data, t-tests were compared to a 0.05 level of significance. The t-test statistic for the control group was 0.0721. That was greater than 0.05 proving there was no significant difference between the mean scores of the pretest and posttest for this group. The t-test statistic for the treatment group was 0.0084. That was less than 0.05 proving there was a significant difference between the mean scores of the pretest and posttest for this group. (see Table 3) This difference shows that students who used a multi-sensory approach in addition achieved greater gains than those who did not use a multi-sensory approach.

**Table 3  t-Test comparisons**

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<th>Groups</th>
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<td>Control</td>
<td>0.0721</td>
<td>No significant difference</td>
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<tr>
<td>Treatment</td>
<td>0.0084</td>
<td>Significant difference</td>
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V.

CONCLUSIONS, IMPLICATIONS FOR FUTURE RESEARCH AND RECOMMENDATIONS

Conclusion

This study sought to discover if first grade students taught addition through a multi-sensory approach would show higher mathematical achievement than those who were not. After analyzing the data, it was discovered that there was a significant difference between the pretest and posttest scores of subjects who had participated in the multi-sensory approach to learn addition than those who had not participated. The TouchMath approach to teaching addition to first graders showed a significant level of mathematical achievement gained. The hypothesis was proven.

Teachers of mathematics have the important job of presenting curriculum material in many different modalities so all children are capable of learning. The TouchMath approach appeals to children through auditory, visual, and tactile senses. The importance of this research study will give classroom teachers one more instructional strategy to use. It will assist them to be prepared to meet the diverse needs of all students learning the concept of addition.

Implications for Future Research

This researcher suggests that further study in the following areas be extended:

- Effects of the TouchMath approach on gender types
- Pretest scores could be used to adjust the groups
- Effects of the TouchMath approach on learning preference styles
- Effects of the TouchMath approach over a longer period of time during the school year
• Effects of the TouchMath approach on subtraction and for more advanced operations of multiplication and division

• Longitudinal studies dealing with the long-term effect of using TouchMath on mathematics achievement

**Recommendations**

• Introduce Touchpoints before the unit on addition so subjects will be familiar with them

• Extend the length of research time

• Keep attendance data to see its effect on the posttest results


Appendix A

Pre-test

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Multi-sensory Approach 27
Appendix B

Posttest

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Appendix C

Touchpoint Poster
Appendix D

Touchpoints for Counting – 1 of 2

**Touchpoints**

<table>
<thead>
<tr>
<th>Touching and Counting</th>
<th>Prerequisites</th>
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<tr>
<td></td>
<td>Counting</td>
</tr>
<tr>
<td></td>
<td>Numeral Identification 1-9</td>
</tr>
</tbody>
</table>

**The Teaching Process**

When demonstrating the touching/counting process:

1. The one is touched at the top while counting: "One."

2. The two is touched at the beginning and the end of the numeral while counting: "One, two."

3. The three is touched at the beginning, middle and end of the numeral while counting: "One, two, three."

4. The four is touched and counted from top to bottom on the down strokes while counting: "One, two, three, four."

5. The five is touched and counted in the order pictured: "One, two, three, four, five." The fourth Touchpoint may be referred to as the "belly button" to help students remember it.
Appendix D

Touchpoints for Counting – 2 of 2

6. The six begins the use of dots with circles. The encircled dots should be touched and counted twice, whenever they appear. Six is touched and counted from top to bottom: “One-two, three-four, five-six.”

7. The seven is touched and counted from top to bottom: “One-two, three-four, five-six,” followed by the single dot: “seven.” The single Touchpoint can be thought of as the nose. Teachers sometimes tell young or remedial students to “touch him on the nose” to help them remember the final Touchpoint.

8. The eight is touched and counted from left to right: “One-two, three-four, five-six, seven-eight.” Tell the young or remedial students that the eight looks like a robot. Count his head first, and then his body.

9. The nine is touched and counted from top to bottom: “One-two, three-four, five-six, seven-eight,” followed by the single dot: “nine.” Tell young or remedial students that the nine is the only number with a “hat”. They should start counting on the “hat” and count straight down the number. Again, the single Touchpoint can be thought of as the nose.
Appendix E

Addition Statement

I touch the largest number, say its name, and continue counting.
Appendix F

Frequency Distribution of Scores — Control Groups
Appendix G

Frequency Distribution of Scores — Treatment Groups

Treatment Group 1 — Pretest

Treatment Group 1 — Posttest

Treatment Group 2 — Pretest

Treatment Group 2 — Posttest

Treatment Group 3 — Pretest

Treatment Group 3 — Posttest
Appendix H

Histogram – Mean Score Comparisons

Pretest and Posttest Scores

<table>
<thead>
<tr>
<th></th>
<th>Control Pretest</th>
<th>Control Posttest</th>
<th>Treatment Pretest</th>
<th>Treatment Posttest</th>
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<td>40.5</td>
<td>32.6</td>
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</table>
Appendix I

Control Group Mean Score Comparison

Pretest and Posttest Scores

Control Group Mean Comparison

![Bar chart showing control group mean comparison between pretest and posttest scores for groups A, B, and C. The chart indicates an increase in scores for all groups, with Group A showing an increase of 8.8, Group B showing an increase of 5.9, and Group C showing an increase of 3.0.]
Appendix J

Treatment Group Mean Score Comparison

Pretest and Posttest Scores

Treatment Group Mean Comparison

+9.9  +12.5  +10.0