THE GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT IN GEOMETRY USING MANIPULATIVES BASED INSTRUCTION

A Thesis

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by
Sarah Jean Pon

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THE GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT IN GEOMETRY USING MANIPULATIVES BASED INSTRUCTION

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by

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Graduate and Professional Studies in Education
Abstract

of

THE GENDER DIFFERENCES IN MATHEMATICS ACHIEVEMENT IN GEOMETRY USING MANIPULATIVES BASED INSTRUCTION

by

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Statement of Problem

The United States is currently underperforming in mathematics and technology. Many studies have shown differences gender differences for specific learning styles and achievement in math. Other factors, such as math self-concept and societal stereotypes also effect male and female interest and progress in math learning. Additionally, studies have indicated that instructional strategies using manipulatives and targeting spatial ability have improved the math learning of both males and females, specifically in the elementary years. The purpose of this thesis is to examine whether students’ gender impacts their math achievement in a Geometry unit, when instruction is designed to tie concrete manipulatives tools to abstract math concepts.
Sources of Data

The research was conducted at a K-6 public school in a suburban area in Yolo County. The subjects included 32 fourth graders with diverse backgrounds from one classroom. The students consisted of 21 boys and 11 girls. All students were given the same instruction, practice and assessment during the Geometry unit. Instruction consisted of manipulatives-based strategies, including model building and manipulatives sorts where students identified and classified shapes based on their characteristics. All participants completed a pre-test, post-test, and post-post-test to analyze the mean growth differences for males and females.

Conclusions Reached

The data indicated that there was a significant difference in the mean growth for male and female students from the pre-test to post-test in their overall test scores. Male participants had a greater mean score growth for the pre-test to post-test in their composite score. An additional finding was also significant, indicating that females’ mean growth from post-test to post-post-test was greater for both the composite score and open-ended question portion of the test.

_______________________, Committee Chair
Rita M. Johnson, Ed.D

_______________________
Date
DEDICATION

This thesis is dedicated to my family who have provided unconditional support in every aspect of my life. Without their patience and encouragement this thesis would not have been possible. This is also dedicated to Kyle and Henry. Thank you for always listening and helping me to focus on the many positive things life has to offer.

Sarah J. Pon
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Sarah J. Pon
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Chapter 1

INTRODUCTION

Boys and girls are different. One is not better than the other; they are just different. As a result, we can expect that a difference exists in how boys and girls learn. However, in many classrooms, the classroom climate, learning style, instructional style, and experiences offered to boys and girls may not address the needs of either gender. (Geist & King, 2008)

Statement of the Problem

There is currently a national concern to be globally competitive in the field of mathematics, however, the United States ranks 32nd worldwide in mathematics proficiency (Peterson, Woessman, Hanushek & Lastra-Anadon, 2011). The United States currently ranks 24th in the percentage of high achieving students internationally, widening the achievement gap between the U.S. and other industrial countries, specifically Asian countries (Lee & Fish, 2010; Petrilli & Scull, 2011). Despite the nation’s continual low international achievement ranking, mathematics remains a focus of instruction in both elementary and secondary education. With the passing of No Child Left Behind (NCLB) in 2001, states were required to annually test reading and mathematics to determine if adequate progress was made, solidifying mathematics as a core subject focus in American schools (Dee & Jacob, 2010).

With this growing concern, there is a research focus on the math achievement of different subgroups, including gender, and how instruction can be tailored to
increase the performance of all students (Lachance & Mazzocco, 2006). Trends in research suggest that girls consistently receive higher grades than males in elementary mathematics classrooms, however the gender achievement gap tends to favor male students in secondary classrooms (Else-Quest, Hyde, & Linn, 2010; Liu & Wilson, 2009). The focus of elementary mathematics tends to be on rote learning strategies that are solely algorithm based. The goal being that if students learn these foundational skills, they will be better able to build upon those algorithms and memorized facts in higher education.

Research focusing on the achievement levels in math has reported inconsistent results (Lachance & Mazzocco, 2006). Most studies favor boys in math achievement overall, while others show increased performance on only specific math-related tasks (Lachance & Mazzocco, 2006). Often achievement in male students is attributed to a more positive attitude toward math based on the greater representation of males in math and science fields (Else-Quest et al., 2010). However, gender differences in math achievement are mostly seen at the middle and high school level, and are relatively non-existent at the primary level (Ganley & Vasilyeva, 2011; Lachance & Mazzocco, 2006; Orhun, 2007). Other studies show no significant differences between mathematics achievement between genders when math is studies as a whole (Center for Education Policy, 2009, 2010; Else-Quest et al., 2010; James, 2007).

The difference sometimes seen in mathematics achievement is attributed to the varied learning styles of males and females and, therefore, how they respond to
mathematics instruction (Orhun, 2007). The majority of studies on learning styles found that males tend to learn best using abstract thinking and had a greater conceptual understanding of mathematics concepts, while female students preferred a rote learning method tied to procedural strategies (Fennema, Carpenter, Jacobs, Franke, & Levi, 1998; Ganley & Vasilyeva, 2011; Lachance & Mazzocco, 2006; Orhun, 2007). Boys also show greater proficiency at tasks involving spatial ability, while girls are more proficient when mathematics requires verbal skills (James, 2007; Lachance & Mozzocco, 2006).

Traditionally math is taught using auditory instruction that focuses on sequential steps for solving problems, but this method does not always integrate the underlying concepts for mathematical procedures (Rapp, 2009). This technique, however, does not always work for male learners, who tend to learn better using conceptual strategies, in lieu of rote and procedural learning (Fennema et al., 1998). According to the National Council of Teachers of Mathematics (2000), students’ mathematical competence is heavily dependent on their conceptual mathematical understanding. Conceptual understanding is often taught using a visual spatial approach that incorporates hands-on manipulative based techniques, where students work to make external representations to aid in problem solving. The conceptual understanding then must be tied into the procedures that students will use to solve problems in order for manipulative use to promote student learning (Puchner, Taylor, O’Donnell, & Fick, 2008). Teachers need to be able to incorporate a method of
mathematics instruction that includes both conceptual and procedural components to promote the success of both male and female students.

The present study attempts to add to the current body of research on gender, learning preferences and mathematic achievement at the elementary level. The study examines the academic success of both male and female students in a classroom where math is taught using an instructional approach that ties manipulative representations of mathematical concepts to the procedures for solving a problem to determine if gender is correlated with academic success.

**Purpose of the Study**

The purpose of this correlational study is to determine whether male or female elementary students at a Northern California school site have greater academic achievement in mathematics when content is taught using a visual-spatial, manipulatives based, hands-on approach to instruction. This study will allow students to experience math content taught in a non-traditional instructional approach where they can visualize the concepts they are learning. Lessons will be interactive and provide students with a conceptual foundation for their future math learning.

**Methodology**

Thirty-one fourth grade children who attend an elementary school in Woodland, California will participate in this study. All students will be taught using a hands-on approach to mathematics instruction, where concepts are taught through the use of manipulatives, then connected back to the algorithmic solution. For the sake of
this study manipulatives-based instruction is defined as an instructional strategy that incorporates models and hands-on materials to represent and solve mathematical problems. For example, counting cubes, connecting blocks and fraction circles, to name a few. The physical representations are then related back to the mathematical procedure being taught. The data that will be collected for the proposed research will be student scores on the teacher-created mathematics assessment. Participants will complete this assessment at three different times; as a pre-test before instruction, a post-test directly after completion of the instructional unit, and as a post-post-test given two weeks after the completion of instruction. Student performance on the assessment will be analyzed by comparing the scores of female to male students. The null hypotheses are:

1. There is no difference between the growth in the overall test scores from the pre-test to post-test for male and female students.
2. There is no difference between the growth in the overall test scores from the pre-test to post-post test for male and female students.
3. There is no difference between the growth in the overall test scores from the post-test to post-post test for male and female students.
4. There is no difference between male and female students in the growth in test scores for multiple-choice questions from the pre-test to the post-test.
5. There is no difference between the growth in test scores for multiple-choice questions from the pre-test to post-post test for male and female students.
6. There is no difference between the growth in test scores for multiple-choice questions from the post-test to post-post test for male and female students.

7. There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-test for male and female students.

8. There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-test for male and female students.

9. There is no difference between the growth in the test scores for open-ended questions from the post-test to the post-post-test for male and female students.

Limitations

This study will take place in one classroom with only thirty-one fourth grade students and, therefore, the findings may not be representative of other elementary school populations. In addition, this school where this study will take place is located in community with a majority of affluent families. Most parents identify with the lower-to-middle class population and home academic support varies from family to family.

Participants’ attitude and perception of self-ability in mathematics must also be considered. Prior research shows that both of these variables influence student achievement in math. Gender bias, stereotypes and roles may also have an affect on academic achievement in mathematics. Race and ethnic background will not be controlled. Furthermore, students will begin the instructional unit with different prior knowledge and experience using manipulatives and hands-on techniques. The
familiarity with making visual representations of mathematical concepts might give a participant an advantage over another participant who has no such prior experience.

**Theoretical Basis**

Piaget’s Theory of Cognitive Development and Gardner’s Theory of Multiple Intelligences (MI) are the theoretical bases of this thesis. Piaget (1973) identified stages of cognitive development that each child progresses through during maturation. In each stage of development, thought processes are described as they relate to learning concepts. Piaget believed that when the developmental stages where used by educators to inform instruction, the best possible learning outcomes would occur.

Gardner (1999) believed that a student’s intelligence was important to their education. Gardner outlined nine types of intelligence that assist learners in processing information. Each intelligence details the way someone identifying with that intelligence learns best. Gardner (1999) also stressed that for students to access the curriculum, teachers should allow them to interact with their natural intelligence in order to connect with the concepts they are learning.

**Definition of Relative Terms**

*Achievement* - the relative growth between the pre-test and post-test

*Gender* - the behavioral, cultural, or psychological traits typically associated with one’s sex (Gender, 2012)

*Learning Style* - the methods and modalities through which and individual learns most successfully (Geist & King, 2008).
Manipulatives - physical objects that are used as teaching tools to engage students in the hands-on learning of mathematics (Boggan, Harper & Whitmire, 2010).

Organization of the Thesis

Chapter 1 includes the introduction, statement of the problem, purpose of the study, methodology, limitations, theoretical basis, definition of relevant terms, and organization of the thesis.

Chapter 2 will include a review of literature. Included will include the role of mathematics in the United States today, learning theories associated with mathematics education, a discussion of gender and learning styles, and an overview of research on manipulatives usage in the mathematics classroom.

Chapter 3 will explain the methodology, including information about subjects, testing instruments, research design and procedures. Chapter 4 will report findings of the study, including data, and statistical calculations. Chapter 5 will contain the findings, a summary, conclusion, and recommendations for future research.
Chapter 2

REVIEW OF RELATED LITERATURE

The review of literature first introduces the role of mathematics in education in the United States. The following section presents the learning theories associated with mathematics learning and relevant to manipulatives based instruction. The third section examines various gender theories and academic achievement in mathematics. The next part discusses research around the use of manipulatives in classroom mathematics instruction. The final section summarizes main points from the review of literature.

Role of Mathematics in the United States

The Importance of Mathematics Education

Mathematics education is a content focus of the education system in our country. Since the start of the twentieth century, mathematics is at the foundation of educational systems across the United States, providing the practical skills necessary for building, innovation, and commerce (Popkewitz, 2011). The push for children to have a strong mathematics education intensified following the Soviet Union’s launch of Sputnik into outer space in the 1960s. Since the United States did not have the technology to launch a satellite first, the public demanded a more rigorous education system that focused on preparing students adequately with increased mathematics and science instruction (Saracho & Spodek, 2008). The focus on mathematics curriculum in K-12 education continues today following the passage of No Child Left Behind.
(NCLB) which requires schools to test students, in grades three through eight, annually in mathematics.

**Job Requirements**

Large portions of jobs in the 21st century economy require mathematics skills that are beyond a basic level. In addition to jobs, advanced math skills are required for many daily skills as an adult, such as, shopping, investing, paying a mortgage, and understanding sports and politics (Hyde & Mertz, 2009).

Math skills are also a crucial component of advancement and innovation in the United States’ economic productivity. Prior research in economic trends indicate that increasing math proficiency in the United States could lead to an increase in GDP growth per capita. According to Michael Brown, a Nobel Prize winner in medicine, math and science are the “engines of innovation” promoting development and advances in technology, the economy, and engineering (Peterson et al., 2011, p. 18).

**Math Achievement in the United States**

Given the world economy, it is necessary to view math achievement on a global scale to assess performance. In one study, Japan outscored US children on math assessment involving computational and problem solving tasks. A study compared groups of Japanese and American fifth graders who took a 33-item mathematics test. Results indicated that the Japanese participants outscored the American students by answering more items correctly, suggesting a clear discrepancy between mathematics achievement in the two countries (Mayer, Stanley & Tajika, 1991). An overview of
the Program for International Assessment (PISA) examination reported similar findings. The report indicated that the United States produced more low achieving students than Germany, France, Italy, Japan and the United Kingdom combined, in both reading and mathematics (Petrilli & Skull, 2011).

In an international executive summary comparing American students’ proficiency in math and reading with 65 other developed countries, the United States ranked 32nd in mathematics proficiency. Participants completed the Program for International Assessment (PISA) examinations in all participating countries. The representative sample of American students tested at a 32% proficiency rate, which is well under half of the 75% of students who tested proficient in Shanghai. In addition, California is ranked 41st among the states with only a 23.9% proficiency rating in math (Peterson et al., 2011). The clear discrepancy between the percent of students who are proficient in math, and the over two thirds of the students who are not, calls for the need to look at our math education in depth, and utilize research based strategies to promote proficiency growth.

**Learning Theories Relevant to Mathematics Instruction**

**Piaget’s Cognitive Development**

Jean Piaget is a Swiss psychologist who outlined children’s thinking as series of developmental stages. Cognitive development is known as the process by which environmental experiences and biological maturity determine how a child constructs
knowledge (Piaget, 1973). According to Piaget, there are four stages of cognitive development.

The four stages, the sensorimotor period, the pre-operational period, the concrete operational period, and the formal operational period, are experienced by each individual in that order and are associated with specific age groups. The sensorimotor stage was from birth to two years of age, which is when the child begins to use thought, memory and learns to imitate others. The second stage, pre-operational, occurs around ages two to seven years old. In the pre-operational stage, children began to think symbolically and use language. Between the ages of seven and eleven, children enter the third stage, concrete operational. During the concrete operational stage, children learned to solve hands-on, concrete logical problems. These children could also understand abstract geometry and the relationship between concrete manipulative objects and the abstract symbols associated with those representations. The final stage of cognitive development occurred from age eleven until adulthood. In the formal operational stage, individuals were able to solve problems that are entirely abstract, without concrete manipulatives, using logic (Piaget, 1973). Piaget suggested that educators use these levels of cognitive development to inform instructional decisions and pedagogies to best reach their audience.
Gardner’s Multiple Intelligences

Intelligence, or one’s capability of learning, is a key component in the understanding of any academic processes. Howard Gardner is one of the most prominent advocates of the concept of multiple intelligences. Garner’s theory of multiple intelligences suggested that people use a multitude of intelligences in any learning situation to help them process information (Gardner, 1999).

Gardner’s theory outlined seven different intelligences: intrapersonal, interpersonal, musical, bodily kinesthetic, spatial, logical-mathematical, naturalist, and linguistic. Intrapersonal intelligence involved the self, or the ability to use one’s understanding about who they are, or self-knowledge, to accomplish academic tasks. Interpersonal intelligence relied on developing relationships, and the ability to understand other people. People who possess this kind of intelligence often work best in social situations and have good leadership skills. Musical intelligence was used to understand musical concepts, and engage in the process of creating and appreciating music. Bodily Kinesthetic intelligence allowed people to use physical means to construct and represent ideas and concepts. Spatial intelligence was the ability to represent spatial information, and manipulate visual representations of space. Logical mathematical intelligence was defined as the capacity to use, categorize, and classify numbers correctly. Linguistic intelligence involved words and language and the ability to use language correctly through both speaking and writing (Adams, 2001). The final intelligence, naturalist, was the ability to understand and correctly observe natural
patterns and systems (Gardner, 1999). According to Gardner, each child might use a variety of intelligences, but will have strength in one type of intelligence.

Gardner (1999) expanded on individual intelligence differences suggesting that educators use knowledge of these differences to inform pedagogy decisions. The idea being that if students are taught to using modalities in line with the intelligence that is their strength, they will more likely internalize the concept and curriculum. Adams (2001) suggested methods for using Gardner’s Theory of Multiple Intelligences in the classroom by connecting the intelligences with the National Council of Teachers of Mathematics Process Standards. Adams suggested using a variety of methods to reach students including building physical models, using manipulatives, bodily movement, and simulations to help build understanding of concepts. She also proposed that educators give students choice in solving problems and let each student arrive at a solution method in a form that best suited their needs. Adams went on to explain the importance of students’ exposure to a variety of different solution strategies, in order to recognize that there are multiple methods for problem solving and acquiring knowledge.

Douglas, Burton, and Reese-Durham (2008) studied the difference that Multiple Intelligence based instruction can have on the academic achievement of students in mathematics. One group was taught using multiple intelligence strategies, while the other was taught using direct instruction strategies. Comparing the results of the pre and posttests, students who received instruction based on Multiple
Intelligences increased their scores more than those who were taught using direct instruction (Douglas et al., 2008).

Support for using a variety of modalities for mathematical thinking is also found by cross-referencing Multiple Intelligence and Cognitive Development theories. Gardner (1999) emphasized the need for learning activities where students are engaged through construction of knowledge while building, experimenting, and manipulating objects. Woolfolk (2001) explained that especially during Piaget’s Concrete Operations stage, children need hands-on experiences to further their level of understanding and cognitive development.

**Gender and Learning**

**Learning Styles**

Educators must acknowledge that all students learning differently, using a variety of intelligences, prior experiences and cultural context. This learning difference can be seen when comparing the ways in which both boys and girls learn mathematics. Gurian and Stevens (2011) synthesized brain research over the past two decades to identify areas where boys and girls differ in learning style. The first area of difference is reasoning strategies. Boys tend to use more deductive reasoning strategies, which rely on establishing a clear conceptual background of a topic, then applying the principal to individual problems, or cases. Girls, on the other hand, tend to use more inductive reasoning, where they first learn specific examples, then learn generalize it more to the concept later (Gurian & Stevens, 2011).
The second area of learning style difference is the need for movement. According to Gurian and Stevens (2011), boys tend to need to move around more while learning, which stimulates brain activity, while girls do not need as much movement. Boys also get bored more easily than girls, which require stimulants to maintain their attention. Another area of learning style difference is seen in the use of symbolism. Boys are more comfortable using symbolism, such as pictures, graphs and objects, to represent concepts, where girls often prefer written representations, such as numbers or words (Gurian & Stevens, 2011).

Geist and King (2008) explained gender learning style differences that relate to Gardner’s Multiple Intelligences. According to Geist and King, girls tend to be more auditory learners, who learn by reading and writing things and understand problems by writing down information. Boys, on the other hand, are more likely to be visual kinesthetic learners, which means the learn best by using objects or concrete materials to solve problems (Geist & King, 2008). Although most students may benefit from learning to solve mathematics problems using hands-on manipulatives, students who are kinesthetic learners will be able to access the content much more easily than by completing problems on a worksheet. Considering these differences, educators must find strategies to adapt lessons to reach both genders in their classroom.

What does this mean for how educators teach their classrooms? Gurian and Stevens (2011) suggested ways in which educators can enhance the learning experiences of both genders in the classroom. It is suggested that manipulatives should
be utilized in the classroom whenever possible. According to Gurian and Stevens (2011), teachers who employed this strategy during instruction found that boys were better able to access the concept and content, where girls struggled and needed more guidance to manipulate the concrete objects. The studies conducted involved obtaining teacher testimonies regarding their experience using manipulatives during instruction. One teacher used pretend money to teach about addition and counting change. She found that while the boys were better at counting the pretend money, girls learned the concept best by writing the amounts of money down on paper and then adding (Gurian & Stevens, 2011).

Geist and King (2008) also found this gender difference and suggest allowing students to solve the problems in the way that best suits their learning style, or teaching both ways to solve a problem. In order for both boys and girls to learn effectively in the classroom, it seems that, concrete materials, abstract concepts, and procedural techniques must be utilized.

**Achievement**

Researchers have been concerned about gender differences in learning because of the effect that learning styles, attitudes and stereotypes can have on mathematics achievement. The stereotype that males are more successful in mathematics is longstanding, but not scientifically proven. These stereotypes, however, do influence the attitude and biases held by many students in the United States (Else-Quest et al., 2010).
Cvencek, Meltzoff, and Greenwald (2011) conducted a correlational study comparing gender identity and self-concept in relation to math ability. A sample of 247 American students completed Implicit Association Tests and self-report measures to determine their level of math self-concept. Participants completed a self-report with Likert-scale questions, where they were shown pictures and had to identify attributes the believed the character, either male or female, possessed. Next, participants participated in a child IAT, which is a computer-based program that provides a pictorial representation and asks the participant to sort these into categories. For example, participants had to associate a behavior or person with one of four categories: girl, boy, reading, or math. Differences were found between boys and girls between six and ten years of age. Boys identified with math more strongly than girls and both genders identified the stereotype associating math with boys. On the self-report assessment, boys more often identified with pictures of their same sex counterparts doing math, than girls. The results also indicated that the significance of these findings increased with grade level (Cvencek et al., 2010).

This discrepancy in attitudes and gender stereotyping is seen in later years as well. In a meta-analysis on gender differences in mathematics, Else-Quest et al. (2010) used data from TIMSS and PISA to test the gender stratification hypothesis; the hypothesis that in areas where there are more gender differences and less equality, there will be greater discrepancies between math achievement and performance. The analysis reported that males tend to show a more positive attitude toward mathematics.
in high school, even though the gap is small in younger years. In the analysis it was also found that overall girls associate a lower self-confidence with math abilities and higher reported anxiety levels. Therefore, the small achievement gap between genders in high school, may be attributed to males’ greater reported level of self-confidence. The meta-analysis also found that differences in achievement were significantly correlated to differences in self-confidence for both genders. While self-confidence was an indicator of achievement, gender equity was not found as a positive predictor of math achievement (Else-Quest et al., 2010). However, despite the stereotypes about girls’ inferiority in mathematics, achievement test scores show little consistent evidence to support boys’ higher performance.

In a meta-analysis of mathematics achievement research, Lindberg, Hyde, Petersen, and Linn (2010), sampled data from 242 studies, representing over one million participants to find that there is no significant gender difference in mathematics achievement or performance. The study did indicate that achievement differences are often found in elementary years, favoring girls, but these discrepancies often disappear by high school. The study went on to report that there is a small gender difference in high school based on the depth of knowledge that is measured by the test, indicating that boys are favored in the area of complex problem solving in high school. The meta-analysis also reported decreased gender differences over time from the earliest study to the most recent study that was analyzed (Lindberg et al., 2010).
According to the report, Subgroup Achievement and Gap Trends in California, in 2010, 15% of both boys and girls scored at an advanced level, and 45% of both boys and girls scored proficient in mathematics (Center for Education Policy, 2010). The Nation’s Report Card (2011) also reported a narrowing achievement gap between male and female students, highlighting that, on average, males scored only one point above their female classmates on the National Assessment of Educational Progress (NAEP, 2011).

There are a few proposed explanations for the decrease in the mathematics achievement gap between genders. First, the amount of girls and boys taking similar high level math classes is relatively similar in high school, with 7.7% of boys and 7.8% of girls taking calculus. Secondly, the decrease in male dominance in mathematics can be credited to how teaching practices have evolved to accommodate the learning styles of both genders (Lindberg et al., 2010). Although gender differences are disappearing in overall assessments of mathematics, some discrepancies still exist in spatial and geometry related tasks.

**Geometry**

Gender differences in geometric tasks and overall spatial ability are apparent in previous research. Spatial ability is known as the task of manipulating objects, either concrete or visual, which is crucial to an understanding of geometric concepts, such as identifying triangles, circles, angle measures, and types of polygons. In a study of 8th grade students, Ganley and Vasileya (2011) examined if the level of spatial skills
predicted math achievement between sexes. Participants were given a test of mental rotation ability to determine if overall spatial ability contributed to their classroom grades and state administered standardized test scores. The results indicated that, although both gender groups had similar achievement, special ability was a significant predictor of math achievement, specifically in male students (Ganley & Vasilyeva, 2011).

Gender differences can be seen across different age levels for some math cognitive abilities. In a recent study, Keith, Reynolds, Roberts, Winter, and Austin (2011) conducted a test on children from ages 5-17 using the Differential Ability Scales, and, using a multi-group mean structural analysis, found gender differences across age levels. Girls showed advantages in free recall memory, processing ability, long-term retrieval memory, where boys showed greater advantages in visual-spatial ability (Keith et al., 2011). It is clear that these differences could have an impact on student learning, and teachers should be aware of the implications on their classroom assignments and tasks.

Gender differences were also found in spatial ability at a young age. In an experimental study, Tzuriel and Egozi (2010) tested a sample of 116 first grade students using a mental rotation test to determine pre-existing spatial ability. The participants were split into an experimental and control group. The experimental group participated in an instructional program that aimed at improving visuospatial skills, and the control group participated in an alternative program that did not focus on
spatial skills. Results indicated that the gender differences in spatial ability that appeared after the initial screening disappeared following the treatment program (Tzuriel & Egozi, 2010). This study indicates that while there may be inherent differences in spatial ability at a young age, with targeted instruction, and experiences with spatial orientation tasks, students can increase their spatial skills.

Despite the apparent difference in spatial ability of male and female students, manipulative tools can be successful in aiding both genders. Pacilli (2010) conducted a study comparing the math achievement of students who were taught geometry using a Geo Leg Manipulative tool. The research was conducted using 317 junior high students taking a geometry course in either a control classroom that used traditional methods of instruction, or a test classroom that used the manipulative tool to supplement the curriculum. Overall, no significant gender differences were found in math achievement and both gender groups benefited from the use of this manipulative during instruction (Pacilli, 2010).

Manipulatives and Mathematics

Using Manipulatives to Teach Mathematics

Manipulatives were found by many researchers to be valuable tools that allow students to experience learning through the use of concrete objects. Manipulatives, in relation to this study are defined as the physical objects that students use in mathematics to represent more abstract algorithms or solution strategies. These physical objects are found in most classrooms in the form of Cuisenaire rods, fraction...
circles, base ten blocks, and geometrical shapes. Manipulative include both pictorial and virtual materials, but for the purpose of this study, manipulatives will be solely concrete, hands-on objects.

According to Kamina and Iyer (2009), using manipulatives helps teachers to bridge between the concrete objects and the algorithm, or abstract concepts, which students are required to know. In this scenario, teachers become the mediators between the objects and the procedure, and must assist students in making that connection. The guide to implementing manipulatives in the classroom involves three steps: exploration, scaffolding, abstraction (Kamina & Iyer, 2009). Exploration is a step where students learn to use the manipulatives and attempt to find their own way to solve a problem. Scaffolding requires teacher guidance and questioning to help students solve a problem using the manipulatives. The third step, asks the teacher to facilitate the transfer from concrete objects to a procedure, or algorithm with numerals. The third step is crucial in order for students to connect conceptual thinking to abstract thinking.

Manipulatives must be used correctly and appropriately in order for them to assist in effective mathematics instruction. Boggan et al. (2010) explain how to correctly and successfully use manipulatives in a classroom setting. First, the manipulatives should be appropriate for both the goals of the lesson and the students’ academic level. For example, single counting cubes can be used at the younger grades, while colored rods can represent larger numbers in a higher grade. Secondly, teachers
must give students time to explore and “play” with manipulatives so they are not viewed as toys during instruction time. This exploration will also allow the students to work with the manipulatives with no goal in mind, but just with the purpose of understanding how they work and move (Boggan et al., 2010).

Puchner et al. (2008) conducted a case study examining four elementary school teacher’s use of manipulatives. All four lessons were observed, the teachers conducted assessments, and results were provided to the researchers. All four of the lessons were found to be unsuccessful based on the teachers’ inappropriate use of the manipulative tools. The sixth grade lesson focused on using manipulatives to explain the mathematical reasoning behind multiplication. This was proven unsuccessful, however, because the students already had extensive experience with multiplication. One condition outlined by the researchers is that the material taught using manipulatives must be relatively new in content for the students or it will serve no purpose (Puchner et al., 2008). In the third grade lesson on place value, the teacher directed the entire lesson step by step, leaving no time for students to problem solve or explore with the manipulatives on their own. As a result, the students tied to conceptual meaning to the manipulative, but just moved them around as instructed by their teacher. Puchner suggests that teachers give the exploration time, so students can come up with their own understanding, then the teacher can lead the students in a guided problem solving with the manipulatives. Despite these unsuccessful lessons, if
Manipulatives are used following these guidelines, research suggests that mathematics achievement will increase.

**Manipulatives and their Relation to Achievement**

The benefits of using manipulatives to support mathematics instruction are evident in mathematics research. In a comparative study, Burns and Hamm (2011) taught two groups of fourth grade students, one using concrete manipulatives, and the other using virtual manipulatives on a computer. Burns used both a pre and posttest to determine that the point gains on the posttest were greater for students who were taught using the concrete, hands-on manipulatives. She cautions educators to use manipulatives as a tool to reinforce math concepts, but that the manipulatives are most successfully used if they are tied to the algorithmic processes (Burns & Hamm, 2011).

Sowell (1989) conducted a meta-analysis of 60 previous studies to determine effects of manipulative material usage on mathematics instruction, specifically focused on achievement and student attitudes toward mathematics. Types of manipulatives were compared with control groups in most of the studies. Sowell concluded that the use of concrete instructional tools indicated a better performance in mathematics, and those students who participated in mathematics using the manipulatives expressed a more positive attitude toward mathematics in general (Sowell, 1989).

Other experimental research advocates for the usage of concrete manipulatives in the classroom. Munger (2007) studied the benefits of using manipulatives in the
classroom to teach mathematics. Using two third grade classes, consisting of 52 total students, teachers taught the same lessons, one using hands-on manipulatives and the other using only paper pencil tasks. Results of a post-test indicated that students in the experimental group, using concrete manipulatives, scored higher than those without manipulatives based instruction (Munger, 2007).

**Conclusion**

Students in the United States have failed to learn mathematics concepts fundamental for job success and do not measure up to students from other countries (Saracho & Spodek, 2008). Gender differences in achievement in elementary school leave the boys, who are naturally more kinesthetic learners, behind the girls in terms of concept mastery until high school when the achievement gap widens in favor of male students (Lindberg et al., 2010; Gurian & Stevens, 2011). Research indicates that the gender differences we see in math achievement are correlated with gender stereotypes and student self-concept about math ability (Else-Quest et al., 2010; Lindberg et al., 2010; Cvencek et al., 2010). However if educators use research based instructional strategies, this gender difference could be significantly reduced.

Research has shown that the use of manipulatives as tool to activate conceptual knowledge in mathematics will lead to increased achievement and mastery in both boys and girls (Burns & Hamm, 2011; Munger, 2007; Sowell, 1989). Unfortunately, manipulatives are often not properly used by many elementary math teachers (Prucher et al., 2008).
Many studies have suggested the importance of using manipulatives in the classroom and the impact it has on students’ achievement and attitude towards mathematics (Burns & Hamm, 2011; Munger, 2007; Sowell, 1989). Since research indicated that using manipulatives effectively could lead to greater academic achievement in mathematics, it is important to continue to study whom this strategy benefits and how much it can help. For manipulatives to become a crucial and necessary part of mathematics instruction, it must be researched and valued by educators in the field.

As a result, the present study seeks to examine the gender differences in math achievement during a fourth grade geometry unit, when instruction is enhanced with manipulatives techniques. The research question this study aims to address is whether the use of manipulatives to teach geometry concepts is more effective for one gender than the other.
Chapter 3

METHODOLOGY

The purpose of this study was to determine whether gender would be a predictor of mathematics achievement, when it was taught using manipulatives based instructional strategies. To research this question, gender was used as the dependent variable to see which gender made the greatest improvement in the mathematics unit. A pre-test was administered to a convenience sample of 32 fourth grade students. All participants received four weeks of instruction in various geometric concepts tied to California fourth grade academic content standards. Instruction incorporated manipulatives and hands-on experiences to enhance student learning. Following the month of instruction, students were given a post-test, and the increase in students’ scores from the pre to post test was computed for each participant.

Subjects

The research was conducted at a K-6 public school in a suburban area in Yolo County. The subjects included 32 fourth graders with diverse backgrounds from one classroom. The students consisted of 21 boys and 11 girls. All students were given the same instruction, practice and assessment during the Geometry unit. Due to attrition, two students were dropped from the data collection because they joined the class after the study began or left the class before the post-test was administered.
**Instrument**

The same assessment was used for the pre-test, post-test, and post-post-test for all participants (see Appendix A). The assessment consisted of eight multiple-choice questions that involved identifying geometric terms and vocabulary recall. Each multiple-choice question offered a choice of four responses. For two of the eight questions students had to look at a group of shapes and decide what they all had in common. The remaining six multiple choice questions asked students to look at a picture, or read a descriptive sentence, that the students had to use to identify the vocabulary terms. The final five questions were open ended and required students to apply their knowledge of vocabulary to pictures and create a visual themselves. Two questions from the open-ended section asked students to classify triangles by their angles and sides. Students had to come up with the vocabulary on their own. One of the questions required computation; students solved for the radius of a table when given the diameter measurement. For the final open-ended question students had to use a ruler to draw a picture of different kinds of lines and label angles.

The test was given via paper and pencil to each student in a whole class setting. Students were given a one hour time block to complete the assessment. The assessments were scored using a key for the multiple-choice questions, and a scoring rubric for the open-ended questions (see Appendix B).
Research Design

An experiment was designed to analyze the effect of instruction with manipulatives on fourth grade students’ academic achievement in Geometry. The independent variable was the students’ gender identification, either male or female. The dependent variable resulted from the growth in score that students made from their pre-test to post-test. All participants received the same method of instruction over the four-week instructional unit. Instruction consisted of PowerPoint presentations of content, note taking, the utilization of a vocabulary word wall, manipulative sorting and classifying, and manipulative modeling of vocabulary concepts (see Appendix). The instruction was conducted in a whole class setting approximately 90 minutes per day for the entirety of the four-week experiment. All the instruction and testing of students was done by the author in her own fourth grade classroom. Permission to conduct this experiment was obtained from the site administrator and parents were informed during the Back to School Night presentation. No parental consent forms were needed since the research was part of normal school instruction.

Treatment

Throughout the experiment, a variety of instructional strategies were utilized with the participants. Each lesson consisted of a PowerPoint presentation to introduce vocabulary, which was based on lesson topics from the Envisions Math Program for Fourth Grade (see Appendix). During the presentation, the researcher identified a geometric figure and students modeled the figure using marshmallows and toothpicks.
In the first lesson, marshmallows were identified as points, or a specific point in space, and toothpicks were identified as lines, or a series of points that goes on forever in both directions. Therefore, a line segment would consist of a toothpick with a marshmallow on each end, etc. Using this model, all polygons and geometric figures were built and glued on to a construction paper mat to preserve them for future reference. Pair share strategies were used for students to dialogue about the differences between their models. For example, how is a line different from a ray? Students actively used both descriptors of their models, as well as, clues from the vocabulary definitions to categorize the figures.

Following the modeling portion of instruction, students were given a vocabulary sheet with three columns; geometric figure, definition, example. Students glued these sheets into their math notebook, and took notes on the organizer following direct instruction by the teacher. In the example section, students had to translate their concrete model into a picture diagram of the geometric figure.

The next phase of instruction included a sorting activity. Students in small groups were given a variety of polygons and three-dimensional shapes, specific to the day’s lesson, and asked to categorize them based on the new terms learned that day. For example, following instruction on quadrilaterals, students sorted quadrilaterals into groups; rhombus, parallelogram, trapezoid, square, and rectangle. Groups then shared out some of the difficulties they had sorting, for example, a rhombus is also a parallelogram, or a square is also a rectangle.
Following the hands on portion of the lesson, students practiced what they learned by completing their daily workbook that accompanies the Envisions Math Program for Fourth Grade. The problems in the daily practice consisted on vocabulary identification using appropriate names and labels, as well as classification using geometric terms. Students competed the practice independently, but were able to ask questions and refer to the notes in their math notebook, as well as the models they built, and the manipulatives at their table groups. At the end of each lesson, students completed a three-four question Quick Check Quiz, as part of the Envisions program, to determine their mastery of the concept. The quiz questions were mainly multiple choice, but had open-ended components. Quiz responses and scores were used by the teacher to determine the need for reteaching, but these scores were not factored in to pre-test, post-test, or post-post-test assessments.

Data Analysis

Data from student test scores was entered into an excel spreadsheet. A t test for independent means was used to analyze the data in the Statistical Package for Social Sciences (SPSS) program.
Chapter 4

RESULTS

Presentation of the Data

Past research suggests that mathematics instruction that incorporates manipulatives has a positive impact on students’ learning of mathematical concepts, but there are varied results regarding the gender differences in this positive impact. Therefore, the present research asked whether this type of instruction had a greater impact on the academic achievement of male or female students. An experimental design with gender as the independent variable and growth in test scores from the pre-post test was used as the dependent variable, in order to answer the research question. The null hypotheses were:

1. There is no difference between the growth in the overall test scores from the pre-test to post-test for male and female students.
2. There is no difference between the growth in the overall test scores from the pre-test to post-post test for male and female students.
3. There is no difference between the growth in the overall test scores from the post-test to post-post test for male and female students.
4. There is no difference between male and female students in the growth in test scores for multiple-choice questions from the pre-test to the post-test.
5. There is no difference between the growth in test scores for multiple-choice questions from the pre-test to post-post test for male and female students.
6. There is no difference between the growth in test scores for multiple-choice questions from the post-test to post-post test for male and female students.

7. There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-test for male and female students.

8. There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-post-test for male and female students.

9. There is no difference between the growth in the test scores for open-ended questions from the post-test to the post-post-test for male and female students.

All participants were given the pre-test prior to the four-week instructional period and the post-test was administered following instruction. Growth, or the dependent variable, was measured by comparing the difference in both test scores. A post-post test was also administered three weeks following the post-test, to compare the level of retention in male versus female students. Data was recorded in an excel spreadsheet and compared for statistical significance.
Table 1

*Pre-Test, Post-Test, and Post-Post-Test Scores for Group 1 (Female Students) and Group 2 (Male Students)*

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<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Analysis

Null Hypothesis 1: There is no difference between the growth in the overall test scores from the pre-test to post-test for male and female students. To test the first hypothesis, a t-test for independent means was done. The difference between the group means for the overall Geometry test score for Group 1 (M = 4.70, SD = 3.23) and Group II (M = 7.58, SD = 3.20) was statistically significant, t (27) = -2.29, p = (0.030). See Figure 1.

![Mean Overall Test Score Growth From Pre-Test to Post-Test](image)

*Figure 1. Mean Overall Test Score Growth from Pre-Test to Post-Test.*

Null Hypothesis 2: There is no difference between the growth in the overall test scores from the pre-test to post-post test for male and female students.

To test the second hypothesis, a t-test for independent means was done. The difference between the group means for the overall Geometry test score for Group 1 (M = 5.10,
SD = 2.13) and Group II (M = 5.74, SD = 3.12) was not statistically significant, \( t (27) = -0.576, p = (0.570) \). See Figure 2.

![Mean Overall Test Score Growth From Pre-Test to Post-Post-Test](image)

**Figure 2.** Mean Overall Test Score Growth from Pre-Test to Post-Post-Test.

Null Hypothesis 3: There is no difference between the growth in the overall test scores from the post-test to post-post test for male and female students. To test the third hypothesis, a t-test for independent means was done. The difference between the group means for the overall Geometry test score for Group 1 (M = 0.40, SD = 2.95) and Group II (M = -1.84, SD = 2.27) was statistically significant, \( t (27) = 2.281, p = (0.031) \). See Figure 3.
Null Hypothesis 4: There is no difference between male and female students in the growth in test scores for multiple-choice questions from the pre-test to the post-test. To test the fourth hypothesis, a t-test for independent means was done. The difference between the group means for the multiple choice section of the Geometry test score for Group 1 (\(M = 2.10, SD = 1.197\)) and Group II (\(M = 3.21, SD = 1.51\)) was not statistically significant, \(t(27) = -2.009, p = (0.055)\). See Figure 4.

*Figure 3.* Mean Overall Test Score Growth from Post-Test to Post-Post-Test.
Null Hypothesis 5: There is no difference between the growth in test scores for multiple-choice questions from the pre-test to post-test for male and female students. To test the fifth hypothesis, a t-test for independent means was done. The difference between the group means for the multiple choice section of the Geometry test score for Group 1 ($M = 1.70, \, SD = 1.34.$) and Group II ($M = 2.05, \, SD = 2.01$) was not statistically significant, $t \,(27) = -0.497, \, p = (0.623).$ See Figure 5.

![Mean Multiple Choice Question Score Growth From Pre-Test to Post-Test](image)

Figure 4. Mean Multiple Choice Test Score Growth from Pre-Test to Post-Test.
Null Hypothesis 6: There is no difference between the growth in test scores for multiple-choice questions from the post-test to post-post test for male and female students. To test the sixth hypothesis, a t-test for independent means was done. The difference between the group means for the multiple choice section of the Geometry test score for Group I ($M = -0.40$, $SD = 1.51$) and Group II ($M = -1.16$, $SD = 1.42$) was not statistically significant, $t(27) = 1.336$, $p = (0.193)$. See Figure 6.

*Figure 5. Mean Multiple Choice Test Score Growth from Pre-Test to Post-Post-Test.*
Null Hypothesis 7: There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-test for male and female students. To test the seventh hypothesis, a t-test for independent means was done. The difference between the group means for the open ended section of the Geometry test score for Group 1 ($M = 2.60, SD = 2.55$) and Group II ($M = 4.37, SD = 2.27$) was not statistically significant, $t(27) = -1.915, p = (0.066)$. See Figure 7.

![Mean Multiple Choice Question Score Growth From Post-Test to Post-Post-Test](image)

*Figure 6. Mean Multiple Choice Test Score Growth from Post-Test to Post-Post-Test.*
Null Hypothesis 8: There is no difference between the growth in the test scores for open-ended questions from the pre-test to the post-post-test for male and female students. To test the eighth hypothesis, a t-test for independent means was done. The difference between the group means for the open ended section of the Geometry test score for Group I ($M = 3.40, SD = 1.71$) and Group II ($M = 3.68, SD = 2.03$) was not statistically significant, $t(27) = -0.377, p = (0.709)$. See Figure 8.

*Figure 7.* Mean Open-Ended Question Test Score Growth from Pre-Test to Post-Test.
Null Hypothesis 9: There is no difference between the growth in the test scores for open-ended questions from the post-test to the post-post-test for male and female students. To test the ninth hypothesis, a t-test for independent means was done. The difference between the group means for the open ended section of the Geometry test score for Group I ($M = 0.80, SD = 1.69$) and Group II ($M = -0.68, SD = 1.92$) was statistically significant, $t(27) = 2.061, p = (0.049)$. See Figure 9.

*Figure 8*. Mean Open-Ended Question Test Score Growth from Pre-Test to Post-Post-Test.
Figure 9. Mean Open-Ended Question Test Score Growth from Post-Test to Post-Post-Test.

Summary

This study examined the difference in male and female student Geometry test score growth following a Geometry unit taught using manipulatives and hands-on instructional strategies. Based on the results of the nine t-tests conducted, a significant difference was noted in the test score growth from the pre-post test between the two groups. The results indicated that males’ test scores grew, on average, about three points more than female students’ scores. A possible explanation is that male students benefited significantly from learning the content through manipulatives and a high level of hands-on activities.

The results also indicated a significant difference in the growth of test scores from the post-test to the post-post test between groups. Male students decreased their
scores by about two points on average, where female students increased their scores by an average of less than a half a point. While both groups’ scores decreased, likely due to forgetting the material over an elapsed time, the female students held on to more of what they learned. Finally, the results indicated that there was a significant difference in the growth of open-ended test question scores from the post to post-post-test between male and female students. From the post to post-post tests female students gained an average of about one point, where male students decreased over a half a point on the open ended questions. The male student score decrease might be explained by the absence of manipulatives practice between the post and post-post test, where the female student score increase indicates they may have internalized the manipulatives to a more abstract concept of Geometry.
Chapter 5

SUMMARY, RECOMMENDATIONS, AND CONCLUSIONS

In a contemporary classroom teachers are faced with educating upwards of 30 students everyday. In order to reach these students, the teacher must take into consideration the students’ prior knowledge, learning style, and stage of development. The categories often vary with student gender. Taking into account Piaget’s stages of development (1973), and research on learning theory and hands-on instruction by Fennema et al. (1998), Boggan et al. (2010), and Kamina and Iyer (2009), the researcher examined the relationship between gender and mathematics achievement in Geometry when it was taught using hands-on instructional techniques and manipulatives to enhance conceptual development.

In order to determine the affect of gender on math achievement, specifically using manipulatives for instruction, an experiment was conducted using a group of fourth grade students. Analyzing the growth between pre-, post-, and post-post tests, indicated that male students made greater growth from the pre-test to post-test in their overall score, while female students retained more information, having greater average growth scores from the post-test to post-post test for their overall test score and the open ended test questions.

Conclusion

The data in Figure 1 showed the difference in growth in the overall test scores from the pre-test to post-test for both groups. When the difference in average growth
was analyzed in a two-tailed t-test at the 95% confidence level of significance, the results rejected the null hypothesis that there was no significant difference in the mean growth of test scores between male and female students. The data in Figure 3 shows a significant result rejecting the null hypothesis, indicating that the growth in scores from the post-test to post-post test for overall test scores is greater for female students, who retained more information overall. In Figure 9, significant results reject the null hypothesis to show that female students retained more overall information from the post-test to post-post-test for open-ended questions. Further research should look into the possible explanations of why males could show greater growth from the pre-test to post-test on overall scores, but female students’ scores show more growth from the post-test to post-post-test scores.

**Recommendations**

Additional research that looks into the effectiveness of teaching with manipulatives and hands-on strategies needs to be conducted. Proposing the current study with a larger sample population throughout different age groups would yield a broader data, generalizeable to other populations. In addition, the current study was limited to the school population and demographic in one fourth grade classroom, therefore further explorations of this research question should be investigated using different populations of students. However, the results of this study and review of literature, indicate that instruction with manipulatives has a positive impact on both boys and girls’ math learning, specifically in male students’ performance.
Another topic of focus for additional research is that while males showed overall growth from the pre-post test in overall score, they retained less of the information on average compared to female students from their post-test to post-post-test scores for overall test questions and open ended questions. There are many questions that arise as a result of this difference. First, does manipulatives practice lend itself to more open-ended critical thinking questions, or more objective problems? Second, why did females retain more information for both the overall and open-ended test questions? What does past research indicate about the gender differences in information retention, and how can we apply this to the classroom? Lastly, is there an underlying stereotype in a classroom about gender differences and math performance, and is the level of perceived stereotype correlated with math achievement?

In addition to investigating the previous questions, another avenue for additional research should focus on the use of virtual manipulatives. Many math programs implemented in schools today have virtual manipulatives components. If students have access to these tools, it would be interesting to see how they compare to real hands-on concrete objects. Any study looking into using virtual manipulatives would also have to address the apparent gender differences in spatial ability and manipulating visual objects.

Additional research on the topic of gender differences in math achievement using manipulatives based instruction, or other instructional strategies, should take
into account variables of environment, teaching style, and delivery. Although the current research benefiting both males and females, it is clear that males outperformed females on the post composite test score. Further studies looking into the benefits of instructional strategies should focus on strategies past research indicates benefit both male and female students equally.

The researcher encourages the dissemination of the results of this study to teachers in the greater Sacramento Area in hopes that teachers will be encouraged to try various researched-based instructional strategies in their own classrooms. In addition, teachers should work on incorporating hands-on, manipulatives-based strategies as early as possible in students’ educational careers so they can gain experience with spatial ability and build strong conceptual underpinnings for their future math learning.
APPENDIX A

Pre-Test, Post-Test, and Post-Post-Test
1. Tom dropped 6 toothpicks in the pattern below. Which line is parallel to line U? (8-1)
   - A. Line T
   - B. Line S
   - C. Line W
   - D. Line X

2. Circle X is shown below.

What does line segment YZ appear to be? (8-6)
   - A. A diameter
   - B. A center
   - C. A radius
   - D. A diagonal

3. Which polygon has 8 sides? (8-3)
   - A. Hexagon
   - B. Pentagon
   - C. Octagon
   - D. Heptagon

4. Which type of angle is angle F? (8-2)
   - A. Acute
   - B. Obtuse
   - C. Right
   - D. Straight
5. Iris picked the following shapes out of a bag.

Her shapes did not belong with the ones Manny chose.

Which is the best description of the shapes Iris chose? (8-10)

A. Polygons with more than 4 sides
B. Polygons with parallel sides
C. Polygons with no sides congruent
D. Polygons with a right angle

6. Which polygon has fewer than 4 vertices? (8-3)

A. Pentagon
B. Quadrilateral
C. Triangle
D. Hexagon

7. Which statement is true about the figures shown below? (8-5)

A. They are all rhombuses.
B. They are all quadrilaterals.
C. They are all rectangles.
D. They are all parallelograms.

8. Which geometric terms best describe the triangle? (8-4)

A. Isosceles, obtuse
B. Isosceles, right
C. Equilateral, acute
D. Scalene, acute
Classify each triangle by its sides and angles.

11 The diameter of a circular table is 6 feet. What is the length of the radius?

Name the solid that is described.

12 6 square faces

13 Writing to Explain Draw parallel lines with a line intersecting them on an angle. Label and name 2 different angles.
APPENDIX B

Pre-Test, Post-Test, and Post-Post-Test Open-Ended Scoring Rubric
## OPEN-ENDED QUESTION SCORING RUBRIC

<table>
<thead>
<tr>
<th>Problem #</th>
<th>Description</th>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem #9</td>
<td>Classifying a triangle by its sides and angles</td>
<td>Student correctly classifies the triangle by either its sides OR angles</td>
<td>Student correctly classifies the triangle by both its sides AND its angles</td>
<td>Equilateral or Acute</td>
</tr>
<tr>
<td>Problem #10</td>
<td>Classifying a triangle by its sides and angles</td>
<td>Student correctly classifies the triangle by either its sides OR angles</td>
<td>Student correctly classifies the triangle by both its sides AND its angles</td>
<td>Isosceles or Right</td>
</tr>
<tr>
<td>Problem #11</td>
<td>The diameter of a circular table is 6 feet. What is the length of the radius?</td>
<td>Student correctly solves to find the length of the radius, but does not label the unit (feet).</td>
<td>Student correctly solves to find the length of the radius and labels the answer with the correct unit (feet).</td>
<td></td>
</tr>
<tr>
<td>Problem #12</td>
<td>Name the solid with 6 square faces</td>
<td>Student correctly identifies the geometric solid as a cube.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem #13</td>
<td>Draw parallel lines with a line intersecting them on an angle. Label and name 2 different angles</td>
<td>Student correctly draws two parallel lines and an intersecting line.</td>
<td>Student correctly draws two parallel lines and an intersecting line and labels two angles without the correct notation (using one or two letters to label).</td>
<td>Student correctly draws two parallel lines and an intersecting line and labels the angles using the correct notation with three letters (vertex is the center letter).</td>
</tr>
</tbody>
</table>
APPENDIX C

Geometry PowerPoint
# Geometry

**Credits to: Dr. Rita M. Johnson**  
*Edited by: Sarah Pon*

---

## Joining Some Pieces We Have:
- Two rays joining at a point = an angle
- The joining point is called the vertex

## Angles, Angles and More Angles
- There are many different angles:
  - acute
  - obtuse
  - straight
  - right

---

## Let's Start at the Beginning
- A point
- A series of points going on forever in both directions = a line

## A Plane
- A plane is an endless flat surface

## Combining Angles and Line Segments
- Creates polygons:
  - Regular polygons have equal sides

---

## NEXT...
- A series of points going on in one direction = a ray
- A series of points that has a beginning point and an end point = a line segment

## Types of Lines
- Parallel Lines: Never intersect (except at infinity)
- Perpendicular Lines: Lines that form a right angle (90 degrees)
- Intersecting Lines: Lines that cross through the same point

## Polygons
- A polygon is a closed plane figure made up of line segments.
- Polygons have sides and vertices.
- Side: each line segment in a polygon
- Vertex: a point where two sides meet
Types of Polygons
- Triangle: 3 sides
- Quadrilateral: 4 sides
- Pentagon: 5 sides
- Hexagon: 6 sides
- Octagon: 8 sides

Equilateral Triangle
- Equilateral Triangle: Three equal sides

A Right Triangle
- Right Triangle: a triangle with one right angle (square corner)

Adding more sides we get:
- 5 sides and 5 angles: pentagon
- 6 sides and 6 angles: hexagon
- 8 sides and 8 angles: octagon
- 10 sides and 10 angles: decagon
- 12 sides and 12 angles: dodecagon

Scalene Triangle
- Scalene triangle: no sides are equal lengths

An Acute Triangle
- Acute Triangle: a triangle with three acute angles
  - Ex) equilateral triangle

Triangles
- If we combine three line segments with three angles we get a variety of different triangles.

Isosceles Triangle
- Isosceles Triangle: two sides have the same length

Obtuse Triangle
- Obtuse triangle: a triangle with one obtuse angle
Quadrilaterals
- Four sides and four angles
  - Many different kinds
  - Square
  - Rectangle
  - Trapezoid
  - Parallelogram
  - Rhombus

Building Up
- Start with a triangular base
- Add vertical line segments to each vertex and join them at a point.
- How many vertices? 4
- How many edges? 6
- How many faces? 4

Change the top...
- Start with a cube.
- Add 4 vertical lines and a base with a square top.
- How many vertices? 8
- How many faces? 6
- How many edges? 12

Circle Circle Circle
- Circle: a closed plane figure in which all points are the same distance from the center
- Center: the point in the middle of the circle

Building Up continued
- Start with a triangular base
- Add vertical line segments to each vertex and make a triangular top
- How many vertices? 6
- How many edges? 9
- How many faces? 5

More on circles...
- Radius: any line segment that connects the center to a point on the circle
- Diameter: a line segment that connects two points on a circle and passes through the center

Try Another Base...
- Start with a square.
- Add a vertical line and a base at the top to a single vertex.
- How many vertices? 5
- How many faces? 5
- How many edges? 8
APPENDIX D

Permission for Research
Appendix A

Consent to Conduct Research

Students in Ms. Pon’s class are being asked to participate in research which will be conducted by Sarah Pon, a student in Education at California State University Sacramento.

The study will investigate gender differences in academic achievement in math when it is taught using a hands-on, manipulatives based instructional approach. Students will be asked to participate in three weeks of math lessons on standards-based, grade level material, and use a variety of hands-on materials to help solve problems. These materials may include counting blocks, base ten blocks or fraction circles. Participants will be tested on math content prior to instruction and after the completion of all lessons.

Students who participate will learn to model math problems using tools, as well as numbers. It is hoped that through participating in the study, students will gain a greater conceptual understanding of math content.

All participants will remain anonymous and students will be identified using a number, only known to the researcher, to maintain confidentiality. The location and identity of the school will also remain confidential.

If you have any questions about this research, you may contact Sarah Pon at (530) 219-8252 or by e-mail at spon@dijusd.net.

Your signature below indicates that you have read this page and consent to allow the research to be conducted at your school site.

[Signature]

Principal Signature
APPENDIX E

Background of the Researcher
Background of the Researcher

Sarah Pon earned her Bachelor of Arts Degree in Child Development from California State University, Sacramento in 2010. Her education continued through the teacher credentialing program at California State University, Sacramento, which she completed in 2011. In Fall of 2011, Sarah began studying as a graduate student in the Education program with an emphasis in Curriculum and Instruction. Her interest in math and the use of manipulatives began in Dr. Stephanie Biagetti’s credential preparation course. Through the use of engaging lessons and the manipulatives based math instruction of Dr. Biagetti, Sarah learned how concrete representations of mathematical concepts can be connect to procedural algorithms to enhance understanding.
REFERENCES


Dee, T., & Jacob, B. (2010, September 6). Evaluating NCLB. *Education Next, 10*, 3, 54-61.


Kamina, P., & Iyer, N. N. (2009). *From concrete to abstract: Teaching for transfer of learning when using manipulatives*. Retrieved from DigitalCommons@UConn


