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The Effects of Implementing "Its in the Cards" Into Third Grade Math Classes

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THE EFFECTS OF IMPLEMENTING "ITS IN THE CARDS"
INTO THIRD GRADE MATH CLASSES

by

Marsha Anne Hestad

A Dissertation Submitted to the Faculty of the Graduate
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VITA

The author, Marsha Anne Hestad, is the daughter of Bjorn Mark Hestad and Florence Anne (Ragusì) Hestad. She was born in Evanston, Illinois.

Her elementary education was in the Avoca School District in Wilmette, Illinois. Her secondary education was completed in 1968 at Glenbrook North High School, in Northbrook Illinois.

During her undergraduate studies Ms. Hestad spent one semester abroad at St. Matthias Teacher Training College, a branch of Bristol University in Bristol, England. While attending college in Bristol, she taught in one of the infant schools, and had the opportunity to observe approximately thirty infant schools in the Bristol area. In 1972, Ms. Hestad graduated with the degree of Bachelor of Science, with Honors, from the University of Illinois in Champaign. While teaching in Deerfield, Illinois, she pursued and received a Master of Education Degree, in 1978, from National-Louis University in Evanston, Illinois.

In 1978, she went abroad to set up and head a private American school in Kavala, Greece, where she taught students in grades K-12. Upon her return to the States in 1982, she worked for Alief Independent School District in Houston, Texas. There she gained experience in working with both remedial and gifted students.

In 1984 Ms. Hestad moved to southern Indiana and worked for the Evansville-Vanderburgh School Corporation (EVSC). The gifted curriculum she
wrote for the EVSC was published, distributed, and piloted by teachers in the twenty elementary schools in the district.

In 1985, Ms. Hestad became the Gifted Coordinator K-12, for the Metropolitan School District of Mt. Vernon in Mt. Vernon, Indiana. She was instrumental in developing a K-12 gifted program for the district, as well as developing a gifted “hands-on” social studies program for fourth, fifth, and sixth graders, at a local historic site. “The Museum Connection,” which received national recognition, is still in operation in New Harmony today. Articles which she coauthored regarding this project have been published in Hoosier Heritage, The Indiana Elementary Principal, and The Indiana School Boards Association Journal. In addition, she has made presentations regarding this program at annual meetings for both the National Association for Gifted Children and the Indiana Association for the Gifted.

While serving as Gifted Coordinator, she also worked as a Field Supervisor for Purdue University, observing, evaluating, and assisting teachers enrolled in the gifted education practicum course.

Upon her return to Illinois in 1988, Ms. Hestad has been pursuing a Ph.D. in Curriculum and Human Resource Development from Loyola University in Chicago. She has been involved with the Math Curriculum Improvement Project (MCIP) since that time. While attending Loyola, Ms. Hestad has been the gifted resource teacher for Rockland School in Libertyville. She has been an active member of Odyssey of the Mind since 1985, serving on the State Board of Directors in both Indiana and Illinois.
Ms. Hestad has made a number of presentations regarding both gifted education and Odyssey of the Mind to a number of local school districts and colleges. She holds membership in Phi Delta Kappa, The Illinois Council of Teachers of Mathematics, the American Educational Research Association, the Association of Supervision and Curriculum Development, the Illinois Council for the Gifted, and Odyssey of the Mind.
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CHAPTER I

NATURE AND SCOPE OF THIS STUDY

Introduction

The purpose of this study was to determine whether classroom use of mathematical games at the third grade level would affect student achievement in mathematics, as measured by seven test items, derived from the 1986 National Assessment of Educational Progress. The games are played with a regular deck of playing cards. Face cards and picture cards are removed from the deck and aces are equal to one. The card games focus on problem solving and critical thinking. The mathematical concepts the card games focus on are whole numbers, integers, fractions, and statistics. Students work in groups of two to four to play the games. Students who participated in the project were taught math either by the traditional method or by an advanced method. Control students were taught mathematics by the traditional method, which was the adopted third grade curriculum for the school district. Units of study included place value (up to the thousand's place), and addition and subtraction of whole numbers up to three digits with trading in two places.

Students in the treatment group were taught advanced mathematics for their grade level. In addition to the regular third grade mathematics curriculum,
these students were taught negative as well as positive integers, statistics (mean, median, mode), fractions, and multiplication of three-digit by two-digit numbers (using calculators). Mathematical card games provided the means for teaching these advanced concepts. (See Appendix C for a complete description of the games and rules).

The Need for Reform in Mathematics Education

It is obvious that the present means for teaching mathematics in our country are inadequate. Teachers tend to teach math the way they were taught. They are accustomed to the paper and pencil method of teaching math with lectures and textbooks. Recent research by James Flanders (1987) revealed that K-8 math texts published by three major textbook companies provided roughly 40-60 percent new content for grades two through five. This percentage dropped to thirty by the eighth grade. It is no wonder that students lose interest in math before they even enter high school. Algebra causes frustration and anxiety for students when they are accustomed to persistent drill and practice with a small amount of new information presented to them beforehand. Flanders added that most of the new content in any math text is found in the second half of the book. "On the average the first half of a grade 1-8 book has 35 percent new content, whereas the second half of the book has 60 percent new content" (p.22). When students are the most motivated to learn new material, at the beginning of the year, they are presented with review. Flanders indicated that teachers seldom cover the last few chapters in the text, the chapters which contain the most new material. Therefore, what is most interesting and
important for students to learn is being missed or overlooked in most mathematics classes. Dossey, Mullis, Lindquist, and Chambers, (1988) stated that:

Math instruction in 1986, as in previous years, continues to be dominated by teacher explanations, chalkboard presentations, and reliance on textbooks and workbooks. More innovative forms of instruction - such as those involving small group activities, laboratory work and special projects - remain disappointingly rare" (p. 10)

Despite the advent of new technologies, there appears to have been little movement in the mathematics curriculum away from the past reliance on teacher and textbook. The calculator holds great promise in helping students to compute, yet its availability and usage in mathematics' classrooms is surprisingly limited. . . . while computers have become a more dominant presence in schools, particularly at the upper grades, most of their use tends to be limited to students at the higher range of mathematical ability and has not trickled down to the lower levels of curriculum. (p. 91)

Freeman (1989) stated that textbooks provide little or no information about how much time should be given to instruction in math, what type of content should be presented to different groups, or what level of achievement students should meet. He felt that math texts address some topics and ignore others; they merely guide the choice of which topics teachers teach.

A number of national and international studies regarding the mathematics achievement of our children have all concluded the same disappointing results. If we do not change the way math is being taught, our children will be unprepared to meet the twenty-first century.

In 1983, the National Commission on Excellence in Education released the report A Nation at Risk. Findings from this report indicated that the educational state of our nation was in serious trouble. The report indicated that,
when compared to other industrial nations, our students "were never first or second" but ranked "last seven times" on nineteen academic tests (p. 8). Some twenty-three percent of American adults were "functionally illiterate" and could not perform everyday reading, comprehension, or writing assignments. Thirteen percent of all seventeen-year-olds could also be labeled as "functionally illiterate." For minority groups, this percentage could increase up to forty percent. Many were unable to use higher level thinking skills. Almost forty percent of these teenagers could not "draw inferences" from reading. Only one-fifth could write a persuasive essay and only one-third of them could "solve a mathematical problem requiring several steps" (p.8). Over half of the identified gifted students were unable to achieve what their tested potential indicated. From 1963 to 1980, SAT scores dropped. The verbal score dropped over fifty points and the average math score dropped nearly forty.

Between 1975 and 1980, remedial math courses in public four year colleges increased by seventy-two percent. At that time, remedial classes comprised "one quarter of all math courses taught at such institutions" (p. 9). Business and military leaders were spending millions of dollars on remedial education and training programs for basic skills in reading, writing, spelling, and computers. "The average graduate of our schools and colleges today is not as well-educated as the average graduate of twenty-five or thirty-five years ago when a much smaller proportion of our population completed high school and college" (p. 11).

A Nation at Risk (1983) also reported that in thirty-five of our states only one year of math was required for a high school diploma. In thirty-six states only
one year of science was necessary for graduation. Not only was the curriculum being diluted at the secondary level, the amount of homework being assigned had also decreased.

The same report indicated that schools were not teaching students the study skills required to make good use of time nor the importance of spending more time on school work. It was found that in many other industrialized nations, the time spent on math, biology, chemistry, physics and geography began at the sixth grade level, was required of all students, and was approximately three times what “our most science-oriented” U.S. students took (p.20).

Teaching itself was becoming deprofessionalized. Academically able students were not being attracted to teaching, and many teachers, ranking at the bottom of their graduating class, were being hired. Even after twelve years of teaching experience, teachers had to supplement their incomes with part-time and summer jobs. Shortages of math, science and foreign language teachers was a serious problem. A 1981 survey of forty-five states showed a shortage of mathematics teachers in all but two states. In addition, half of the newly hired math, science and English teachers, were not qualified to teach the subjects they were hired to teach. Fewer than one-third of the nation’s high schools “offered physics taught by a qualified teacher” (National Commission on Excellence in Education, 1983, p.23).

Of our nation’s 200,000 secondary school teachers of mathematics, over half did not meet the professional standards for teaching mathematics. Probably no more than ten percent of the nation's elementary school teachers met contemporary standards for their mathematics teaching responsibilities.

(National Research Council, 1989, p. 28)
Stephen Willoughby, (1984) Professor of Mathematics at New York University and past President of the National Council of Teachers of Mathematics, revealed:

Our underpaid, overworked, underprepared teachers provide the moral and psychic support that should be provided by families and religious groups.

(p. 45)

People preparing to be teachers have the third lowest college entrance exam scores and secondary school standings of all possible majors. Since 1972 there has been a 77 percent decline in the number of high school mathematics teachers prepared, and only 55 percent of those who are prepared choose to teach. Of those who do teach, almost five times as many leave teaching for employment in nonteaching fields as leave to retire. Those who leave teaching for other employment tend to be the better qualified ones.

(p. 46)

What was at risk was not only the future of our nation's youths, but the very state of our country as well.

John Goodlad (1984) observed and studied over 3,000 schools across our country and published his observations in a book entitled A Place Called School. He found in his studies that almost all basic math curricula in the elementary schools included only basic skills. The same skills, only slightly more difficult, were taught in later grades. In the middle school, grades six through nine, students again reviewed basic operations with further attention being given to fractions, decimals and percentages. A few of the schools offered introductory algebra at the eighth grade level, but the general case was not to offer algebra until the ninth grade.

Goodlad found math, from the remedial basic facts to algebra and geometry, was taught almost identically across the country. He found some high
schools offered calculus, trigonometry and computer programming. The math
teachers stated that the texts were a high influence on what was being
presented in class. Goodlad got the impression that math was regarded "as a
body of fixed facts and skills to be acquired, not as a tool for developing a
particular kind of intellectual power in the student" (p.209). Instead of seeing the
upper elementary years as a time to design activities using previously learned
skills, the skills just kept resurfacing. Goodlad found that many math teachers
wanted children to be logical thinkers and able to attack problems for themselves
and think independently, but he found few who went beyond the basic skills, rote
learning, and textbook determination of daily math work. Students are not likely
to develop critical reasoning in mathematics under such circumstances.

In a recent international study, reported in 1986 by the Educational Testing
Service (1989), twelve different student populations were ranked according to
their mathematical ability. Findings were published in the report entitled A World
of Differences. In each of the twelve populations, thirteen-year-olds were
administered a forty-five minute mathematics assessment consisting of sixty-three
questions. With Korea ranking number one, the other eleven populations
comprised three lower-performing groups. Four countries and provinces
performing above the mean were Quebec (French), British Columbia, Quebec
(English), and New Brunswick (English). Performing at about the mean were
Ontario (English), New Brunswick (French), Spain, The United Kingdom, and
Ireland. Below the mean were students from Ontario (French) and the United
States. Our country ranked last of all twelve populations!
It was disclosed that in Korea, seventy-eight percent of the thirteen-year-olds could use intermediate math skills to solve two step problems, compared to only forty percent of the students in Ontario (French) and the United States. In addition forty percent of Korea’s students in the study understood measurement and geometrical concepts and were successful at solving more complex problems, while less than ten percent of those from Ontario (French) and the United States could perform at that level (Lapointe, Mead, & Phillips, 1989, p. 10).

Ninety-five percent or more of the students in Korea, Quebec (French), British Columbia, Quebec (English), New Brunswick (English), and New Brunswick (French) can use basic operations to solve simple problems . . . compared to only 78% of their peers in the United States. (Lapointe et al., 1989, p.18)

The National Assessment of Educational Progress (NAEP, 1988) has analyzed trends in math achievement from four national surveys for 9-, 13-, and 17-year-olds during the thirteen year period from 1973 to 1986. The Educational Testing Service reported the results in The Mathematics Report Card: Are We Measuring Up? It was concluded from the findings that our nation’s youth lacks effective reasoning skills in mathematics.

Every year nearly 1.5 million American 17-year-old near the end of high school without much-needed mathematical reasoning skills. Fully a third of our 13-year-olds haven’t mastered skills universally taught in elementary school. Few youngsters can put mathematics to work effectively in solving everyday problems, and such practical activity is absent from most classrooms. (Dossey et al., 1988, p.7)

Five levels of mathematical proficiency were defined in The Mathematics Report Card. At Level 150, students were able to attain knowledge of simple arithmetic facts. Level 200 represented beginning skills and understanding.
Level 250 was defined as comprising basic operations and beginning problem solving. Level 300 represented moderately complex procedures and reasoning and at Level 350 knowledge of multi-step problem solving and algebra was required (Dossey et al., 1988, p. 12).

The report added that almost all of our nation's students at ages 9, 13, and 17 performed at or above Level 150 in the 1986 assessment. However, at age 17,

only half the high-school students demonstrated an understanding of even moderately complex mathematical procedures (material generally thought to be introduced in junior high schools) and hardly any (6 percent) could solve multi-step problems, especially if they involved understanding algebra or geometry.

(p.16)

A discrepancy between students' expected and actual performance in mathematics appeared in early grades and continued and increased as did grade levels. It was expected that a majority of nine-year-olds would have mastered basic math operations and beginning problem solving at Level 250. Only 21 percent reached this level in the 1986 assessment, and one quarter of them were unable to demonstrate "even beginning skills and understanding" at Level 200 (Dossey et al., 1988, p.49).

At age 13, it would be expected that students could perform at Level 300, with "moderately complex mathematical procedures and reasoning." Only 16 percent of the students at this age were able to demonstrate this ability on the 1986 assessment (p.49).

Only six percent of the 17-year-olds could perform well in multi-step problem solving and algebra at Level 350. Only half of this age group
demonstrated the ability to work at Level 300, which requires a moderately complex understanding of math. In other words, "nearly 1.5 million 17-year-old students across the nation appear scarcely able to perform the kinds of numerical operations that will likely be required of them in future life and work settings" (p.49). Included in The Mathematics Report Card were data from the National Longitudinal Study that reflected declines in the number of students taking advanced mathematics classes for 17-year-olds from 1972-82. The NAEP study indicated that both course-taking and proficiency declined across the 1970's and 1980's. Increases in both areas occurred from 1982 to 1986. The NAEP report suggested that this trend might be due to increased college entrance and high school graduation requirements for math courses in some states.

Even in 1986 a majority of students stated they were taking no advanced mathematics classes. "While nearly 40 percent had taken Algebra II and about seven percent had gone on to enroll in Pre-calculus or Calculus, more than half of the 17-year-olds reported never having taken these courses" (pp. 116-117). The same report added that "although more students appear to have mastered basic mathematics skills and concepts in recent years, few achieve the higher range of mathematics proficiency" (p.7).

The highest level of performance attained by any substantial proportion of students in 1986 reflects only moderately complex skills and understandings. Most students, even at age 17, do not possess the breadth and depth of mathematics proficiency needed for advanced study in secondary school mathematics.
A study by the National Research Council (1989), entitled *Everybody Counts*, indicated that "today's children aren't even prepared for today's jobs, let alone tomorrow's" (p.1). Steen (1989) reported that the majority of students who study advanced mathematics in our country today are white males, with women and minority groups not represented. He added that an average of fifty percent of U.S. students drop out each year after mathematics courses become electives. Blacks, Hispanics, and other minority groups drop out at even greater rates. The National Research Council (1989) warned that as our students drop out of math, international students come to the United States to study math related subjects. "What our own students see as a burden, students from other countries see as an opportunity" (p. 24).

Steen (1989) warned that due to increased teacher retirements and rising student enrollments, it is predicted that there will be a severe shortage of math and science teachers by the year 2,000. At that time, the U.S. will fall short, by over one half million, of the number of scientists and engineers needed to support our needs. Today, almost forty percent of students under the age of eighteen are minorities. We can expect that "by the year 2020, today's minorities will become the majority of students in the United States" (National Research Council, pp. 18-19). In addition, The National Research Council warns that the Hispanic population in our country is increasing at a rate "five times our national average" (p.19).

Rotberg (1990) reported that research scientists and engineers comprise only four percent of American workers. He warned that financial pressures on
college and universities have increased tuition faster than inflation. Due to this situation, minority students find it even more difficult to receive their education from the best institutions. Rotberg added that the time faculty members can spend with minority students can make a major difference in their achievement and retention in science and engineering. He noted that while only “30 percent of students with Bachelor’s degrees in science and engineering enter full-time graduate studies. . . . half of the science and engineering doctoral candidates never earn Ph.D’s “ (p. 673).

Reyes (1988) summarized from research that black students, on the average, take about one less year of mathematics than what is average for the nation. In addition, he felt that there has been little research regarding race and its relationship to socioeconomic status and math performance. Too often, the student achievement of blacks from low SES has been compared to that of whites from high SES, with no consideration of their socioeconomic status. Reyes attested that SES was an important variable to consider, as societal influences (family, community, religious institutions, mass media), send messages to students of different races, sex, and SES, in regards to ability and appropriateness of achievement.

With the rising rate of minority populations, and the shortage of much needed mathematicians and scientists in our nation, the need to provide quality education so that all children can become mathematically empowered has become mandatory.

“Because mathematics is a key to leadership in our technological society uneven preparation in mathematics contributes to unequal opportunity for
economic power" (Steen, 1989, p. 18). The National Research Council (1989) quoted a statement from Workforce 2000:

White males that only a generation ago were thought to comprise the major portion of our country's work force, will represent only fifteen percent of the net additions to the labor force between 1985-2000.

It is, therefore, imperative that we provide quality education for all children, for the benefit of each individual, and the well-being of our nation, as well.

The National Council of Supervisors of Mathematics (1989) disclosed that, in order to be a responsible adult in the twenty-first century, we need to prepare students for the work force of tomorrow. In that world, adults can expect to change jobs often. The skills necessary for these jobs may or may not overlap. However, in educating our youth, we also need to prepare them for more than the workplace. In a recent conversation, Dr. Ralph Tyler warned that our schools are not made to produce workers, but to produce responsible citizens for our democratic society. He believed that if we do not produce responsible citizens, our society will be led by business and special interest groups.

Dossey et al. (1988) indicated that during the last ten years, state legislatures have worked to increase high-school graduation requirements and demanded competency tests for teachers and students. Publishers are adding manipulatives - kits, problem-solving materials and more challenging materials - to accompany math textbooks. Research projects are being conducted and
model curricula are being developed, in an attempt for schools to try and meet
the demands of our changing society.

As a result of the 1986 National Assessment of Educational Progress
(NAEP), there have been signs of progress toward improving mathematics
education. In the 1988 report, entitled The Mathematics Report Card, conducted
by the Educational Testing Service, it was determined that improvements have
been made in regard to student achievement across our nation. The National
Assessment of Educational Progress summarized trends in average
mathematics proficiency for students ages nine, thirteen and seventeen years of
age. The encouraging news from this report revealed that Blacks, Hispanics,
and students living in the Southeast continued to make progress over past years.
However, these gains are primarily from improved performance in “lower-level
skills and basic concepts” (Dossey et al., 1988, p. 16).

Improvement is still needed in all regions of our country in order that
students be provided adequate education in mathematics. To assist our country
in changing the way mathematics is being taught, The National Council of
Teachers of Mathematics (1989a) has issued a draft of new curriculum standards
to help guide reform.

Because today’s math curriculum is inadequate, the whole environment of
learning must change. “What is taught . . . how it is taught,” and how it is
assessed must be reconstructed (NCTM, 1989b, p. 9). NCTM warned that
change is a slow and painful process. Teachers cannot be expected to suddenly
implement new techniques, ideas and materials and change the way they have
taught mathematics.
The NCTM Standards

In order to help meet our children's needs for the twenty-first century, the National Council of Teachers of Mathematics (1989a) has developed a document containing a set of standards for K-12 Mathematics Curriculum. The members of the Council believe that what is contained in the Standards is fundamental content and should be included in all math curricula in schools across the nation. The Standards were developed to establish a broad framework to guide reform in school mathematics. The Standards are to be used as a basis for change so the teaching and learning of mathematics in school is improved. The Council has created a vision of what it means to be mathematically literate in a technological society. The document made the following assumption:

Changing the practices of mathematics teaching depends on teachers, but teachers cannot effect such reform without substantial systematic support and change.

(NCTM, 1989b, p.3)

The standards for teaching were developed to assist teachers in changing their "classroom organization, communication patterns, and instructional strategies," so that the Standards could be implemented effectively (NCTM, 1989b, p.2).

NCTM developed the Standards with the basic philosophy in mind that students do not learn math by "passive absorption and imitation," but rather by becoming actively involved in and doing mathematics (NCTM, 1989b, p.3).
This view of learning, was summarized in *Everybody Counts* (National Research Council, 1989, pp. 58-59):

In reality, no one can teach mathematics. Effective teachers are those who can stimulate students to learn mathematics. Educational research offers compelling evidence that students learn mathematics well only when the construct their own mathematical understanding. To understand what they learn, they must enact for themselves verbs that permeate the mathematics curriculum: "examine," "represent," "transform," "solve," "apply," "prove," "communicate." This happens most readily when students work in groups, engage in discussion, make presentations, and in other ways take charge of their own learning.

All students engage in a great deal of invention as they learn mathematics; they impose their own interpretation on what is presented to create a theory that makes sense to them. Students do not learn simply a subset of what they have been shown. Instead, they use new information to modify their prior beliefs. As a consequence, each student's knowledge of mathematics in uniquely personal.

The features nested in the Standards are:

1) Knowing mathematics is doing mathematics.

2) Some aspects of doing math have changed in the last decade; and

3) changes in technology and the broadening of areas in which math is applied have resulted in growth and changes in the discipline of mathematics itself.

(NCTM, 1989a, p.7)

There are 54 total standards. As defined by the Council, "A standard is a statement that can be used to judge the quality of a mathematics curriculum or methods of evaluation. Thus, standards are statements about what is valued" (p. 2). The standards were designed to provide quality mathematics education for all students, guide the goals of reform, and promote change (NCTM, 1989a). NCTM sees all three goals as equally important. The standards, if applied, "will ensure that all students possess both a suitable and sufficient mathematical background to be productive citizens in the next century" (NCTM, 1989a, p. 256).
NCTM’s (1989a) proposed student goals, if enforced, ensure that students attain the mathematical power necessary for today and tomorrow’s world. Children must be taught 1) to value mathematics; 2) to reason mathematically; 3) to communicate mathematically 4) to solve problems; and 5) to develop confidence in mathematics (p.5).

In meeting today’s student needs, NCTM (1989b) makes four assumptions about the teaching of mathematics for tomorrow’s world.

1) The goal of teaching math is to help all students develop mathematical power.

2) What students learn is connected with how they learn it.

3) All students can learn to think mathematically.

4) Teaching is a complex practice and cannot be reduced to recipes or prescriptions. (p.28)

NCTM (1989a) urges that in order to teach mathematics effectively, expectations must be raised and the breadth of mathematics must be increased. Problem solving calculator use should be employed on a daily basis. Students should be engaged as ACTIVE learners of math, with team work encouraged. Mathematics should be required every year students are in school. Discussion and writing in math should be mandatory. Students should be taught to see the connections between the mathematical concepts presented in math class and the application of these concepts in the real world.

“As society changes, so must its schools” (NCTM, 1989a, p. 5). Because of the dramatic increase of technology in our society today, the nature of life in our country has changed in the home, in business and industry, and in
government. NCTM (1989b) encourages the use of calculators, computers, and "other technological devices as tools for mathematical discourse" (p.33). In addition, they believe that calculators, if used properly in the classroom, can improve the quality of curriculum, as well as learning. The NCTM (1989b) Standards reveal that mathematical reasoning, communication, problem solving and connections should form the core of what is taught today. Students need to communicate mathematics in both oral and written form. Teachers need to help students develop conceptual and procedural understandings of number operations, geometry, measurement, statistics, probability, functions, and algebra and the connections among these mathematical ideas. In addition, NCTM believes that "Solving problems should be the focus of mathematics instruction and should pervade all mathematical activity . . . problem solving is a way of thinking that provides a context for learning and applying mathematics" (p. 72).

Lynn Steen (1989) summarized the actions that NCTM and other national organizations feel are necessary to meet our children's needs. Students need to be engaged in mathematics as "active participants" and have the opportunity to work mathematically in teams (p.20). In order to "reduce fragmentation" in learning, mathematical connections need to be demonstrated, and creativity should be "stimulated" (p.20).

The National Council of Teachers of Mathematics (1989a) has indicated that in order to empower all students mathematically at the K-4 level, the following should be given increased attention in the curriculum:

1) number sense, estimation and meaning of fractions and decimals;
2) mental computation and use of calculators for complex computations;
3) geometry and measurement;
4) probability and statistics and the exploration of chance;
5) patterns and relationships;
6) problem solving;
7) use of manipulative materials;
8) cooperative work and discussion and writing about mathematics; and
9) a problem-solving approach to instruction.

The stage has been set for change, and every state in the nation is making an effort to improve the quality of what is being delivered in the way of mathematics education. However, providing the funding and the technical assistance to implement the Standards effectively and efficiently in our schools is another matter.

It's in the Cards

NCTM (1989a) believes that allowing children to explore math and be active participants, will make them continue to enjoy and be curious about mathematics. Instead of seeing math as dull and routine, children should understand that math is exciting, creative and fun. One way to make math more fun and exciting and to motivate children to learn is to make use of mathematical games.

The mathematical card games incorporated for this study meet the standards set by the National Council of Teachers of Mathematics. "It's In the Cards" is a set of mathematical card games that teach problem solving. The
games were developed by Dr. Diane Schiller, Deborah O'Connor, Catherine Thomas and Debra Ann Jagielski as part of the Math Curriculum Improvement Project (MCIP). One of the goals of MCIP is to improve the mathematics competencies of existing teachers. Another is to develop materials and instructional techniques which build student interest and achievement in mathematics (Schiller, 1989).

The investigator made a visit to the school of a former MCIP participant, who is now an elementary building principal. Her participation in the MCIP project gave her the opportunity to provide staff development for the teachers in her district. She encourages her teachers to implement innovative projects and ideas. The pre-school classroom observed contained seventeen at-risk students who were three to six years old. Twice a week, second graders in the building assist the classroom teacher by doing one-to-one tutoring with the preschoolers. A number of math card games played with regular decks of cards, and created by the teacher, were employed for this purpose. A game teaching the concepts of “high” and “low” numbers was observed. A number of additional math games, created by the teacher, were available for student use. The classroom teacher believed that the games, especially when played with a tutor on a one-to-one basis, helped her students to learn their number concepts. Though she had no empirical evidence to support her ideas, she felt that games, in general, not only helped her students learn academically, but socially as well. Her students learn how to take turns, explore and create, and communicate through games. She added that involving the second grade tutors helped to free her time, so that she could move about the room to observe and assist others.
In a pilot study conducted by the investigator in the spring of 1990, the games "Combinations of Ten" and "Go for Zero" were investigated at the first grade level to determine their effects on learning mathematics. (See Appendix C for a complete description of the games and rules). The game "Combinations of Ten" is played by having students add sums of numbers to make groups of ten. In "Go for Zero" students worked with negative and positive integers (red cards = negative; black cards = positive) to choose two out of three cards in order to arrive at a sum close to, or equal to zero. There were 33 students who comprised the sample in this midwestern suburb. Two intact classrooms from one school were included in the study. One class with 16 students served as the treatment group, and the other class with 17 students, constituted the control group. A pretest-posttest design was employed. The test instrument was designed by the investigator and contained six items. The first five were to measure math skills that were taught by playing the two card games. The sixth question was designed to determine student knowledge necessary to play another game not implemented in this study, "Sum 29."

Students in the treatment group were taught the two card games in two thirty-minute periods. None of the students in the sample had received prior instruction with negative integers. Students played the two card games for a total of four hours during the last two weeks of school. Though the results were inconclusive in regard to the cognitive effects of games, both the teacher in the treatment class and the investigator observed that both high and low achieving students could successfully play them. All of the students seemed to be highly motivated during the game-playing time. In addition, the classroom teacher
noted that students who usually were not accepted socially or had struggled in math all year long were now able to join in group play, as well as enjoy mathematics. The investigator believed that there were some unanswered questions pertaining to the value of using these games to help teach mathematics. If students were excited, motivated, and curious about math when playing them, it was expected that the games would help them learn mathematical concepts. It was concluded that in order to determine the cognitive effects of games, which the investigator believed would be positive, further studies needed to be conducted.

Specific MCIP card games that were incorporated in this study were selected on the basis of their ability to reinforce the NCTM Standards. All of the card games reinforced Standard One, Problem Solving. Students tested, developed, and applied their strategies in order to play the games successfully. The games gave students the opportunity to be active participants rather than passive observers in the learning of mathematics. They had to verbalize and listen to each other's reasoning while playing the games and arriving at solutions. In this manner, all of the games reinforced Standard Two, Communication. Seeing patterns and relationships in numbers, particularly when playing the games “Mean,” “Median,” and “Mode,” “Fraction Nearest to 1,” “Go for Zero,” and “Largest Product” enabled students to practice Standard Three, Reasoning. Standard Five, Estimation, was reinforced when students played “Sum 29” and tried to acquire a sum equal to, but not larger than 29. Students grouped numbers in tens for “Combinations of Ten” and learned place value concepts with “Largest Product.” As a result, Standard Six, Number Sense
and Numeration, was implemented. Whole Number Operations, Standard Seven, was introduced with the games “Combinations of 10,” “Peace,” “Largest Product,” and “Sum 29.” Students learned Statistics, Standard Eleven, when playing the games “Mean,” “Median,” and “Mode.” When playing “Fraction Closest to One,” the implementation of Standard Twelve, Fractions, was facilitated. Calculators were used to play the game “Largest Product.” As numbers were drawn and called one at a time, students placed them, so when multiplying the three-digit by a two-digit number, the largest product could be attained. NCTM (1989a) stated that it was “critical” that calculators be implemented into mathematics programs (p. 19). In this manner, the card games made creative use of technology.

The games tested students’ mathematical skills, as well as reinforced concepts that were taught in their math classes. By playing the games, students were provided the opportunity to be creative in planning strategies and inventing new ways to produce solutions. In this manner, the games encouraged and promoted the development of mathematical thinking abilities. Students’ creativity was enhanced when they were encouraged to make up new games and rules to meet their needs, as well as those of their classmates. In addition, the games broadened the range of content that is normally introduced at the third grade level. Negative integers, statistics, and three-digit by two-digit multiplication problems are generally not included in third grade mathematics curricula. NCTM urges classroom use of hand calculators, which students utilized when playing the game “Largest Product,” for solving complex mathematical problems.
The card games provided an opportunity for students to learn social skills. Students, who normally might not socialize at school or outside of school, learned to play together. Learning rules of play, taking turns keeping score, dealing cards, helping others to compute answers, and understanding how to be a "good loser" were important factors in facilitating classroom socialization.

In addition to their ability to enforce the Standards, the card games offered an economical and efficient means for their implementation. School districts are often limited in regard to the amount of money that can be spent for classroom materials. The MCIP card games, which are played with a regular deck of cards, can be easily obtained by any teacher or parent. Most households have at least one deck of playing cards; therefore, students can share the games they learn with friends and family members at home.

The MCIP card games provided an excellent link between school and home. Parents are often confused as to how they can help their children learn. Often, they can feel threatened by the unfamiliar methods of doing school work or unclear assignments their children bring home. "It's in the Cards" consists of simple games with clear rules of play; games that are not only non-threatening for parents, but enjoyable, as well as motivating.

The Role of Play in Education

Since man appeared on earth, he has enjoyed playing games. The ancient Egyptians belief was that "heaven was a place for music, dancing and games" (Johnson, 1907, p. 26). The Greeks were great proponents of play in education. However, Plato discouraged too many toys for the nursery, as they
discouraged originality. He encouraged “mimic tools” and free play for children to make discoveries for themselves (Johnson, p. 27).

Comenius, who was a seventeenth century educator from Czechoslovakia, thought that children should learn through independent study and activity. The eighteenth century educator, Rousseau, stressed that spontaneous expression, sensory impressions and motivation was necessary for learning to take place. Early in the nineteenth century the Swiss experimental educator, Pestalozzi, investigated the possibility of making education more meaningful by employing concrete examples and “constructive activity” for the learner (Henry, 1974, p. 24). In the same time period, a German educator, Frobel, also promoted the active learning approach.

Perhaps the present day influence of games is a result of their role in England’s history. It can be noted that in the strict environment of the Victorian Era, when children’s movement was often restricted by their adult-like clothing, games that families played were of an educational nature. They were not only a means of entertainment for the family, but they served to teach, as well.

Mary Everett Boole, who lived from 1832-1916 in England, taught children mathematics using her own theories. She believed that natural materials and imagination were the “magic combination to create excitement in mathematics classes” (Perl & Manning, 1982, p. 57). She invented cards marked for the purpose creating curves from straight lines. Colored string was threaded through the cards to make geometric designs. These “Boole Cards” are what we call string geometry today. Mary Boole felt they were essential in teaching geometry of angles and space.
Montessori and Cuisenaire both were advocates of play and game-like activities to teach mathematical concepts. Henry (1974) summarized that as a result of their work and use of manipulatives, this active learning approach not only allows students to explore mathematical ideas and concepts, but also provides the opportunity for teachers to observe their students at work.

John Dewey (1928) believed that both play and work are alike in that they are "active" occupations and a way to involve students actively in the learning process. He believed that games should be an integral part of the educational program. Dewey believed, however, that activity alone was not enough to teach. Activities needed content objectives to meet the needs of the student. In addition to having cognitive value, Dewey also disclosed that play and games provided social values for the student.

Games make learning more enjoyable. In addition to providing pleasure, games can produce excitement, relaxation, and challenge. Playing games can stimulate mental activity and physical activity as well as teach social skills. George Ellsworth Johnson (1907) believed that even animals in their young helpless stage of life,

exercise in playful ways the growing powers by the use of which their ancestors have survived in the struggle for life. . . .education is largely the result of instinctive reaction to environment and of playful practice of the powers by which the animal is to maintain life in its maturity.

(pp. 4-5)

Johnson added that even up to a certain point in the development of civilization, "play . . . has been the chief factor in conserving and training the powers necessary in maturity" (p.6). He attested that "in planning our school systems we have snubbed nature . . . Play is our best great ally in bringing up
our children" (p.6). It was his belief that "Play may achieve an end which is not only in the mind of the parent or teacher but in that of the child as well; and this fact has a most significant bearing upon the transition from play to work in education" (p.17). Johnson affirmed that though many educators recognize the value of play in education, few of them practice their beliefs.

Johnson felt that "the child's pleasurable response to his environment is his play" (p.17).

All play involves work, and children sometimes love to work, even to work for a definite result, as they love to play . . . I hold that it is one of the chief ends of education to develop a habit of joyousness in work. The fear that love of play will interfere with love of work is the most groundless of fears. The more a child loves play the more likely will he be to love work . . . I have no plea for 'sugar-coated' tasks, if they really be sugar coated, but to sweeten work with a real joy in the doing is the high art of the genius in teaching.

(p.18)

In a recent conversation Dr. Ralph Tyler stated that games help to motivate children to learn. Games help to develop interest as well as build self-confidence in children. Dr. Tyler added that the middle and upper class British use games to a great extent to teach mathematics. One need only view present-day television programs in Britain for a short time to realize that many are educational in nature.

Card games have been around for about one thousand years. As Boole believed, it took natural materials and a little imagination to create excitement in the classroom. One can extend this concept to today's classrooms and math curriculum by incorporating games into mathematics instruction.

Using games to teach mathematical concepts reduces math anxiety in children (Henniger, 1987). With reduced anxiety, students' self confidence in
math builds. Students who are more self-confident in mathematics will achieve more in math (Kloosterman, 1988). Recent studies cited by Oakes (1990) revealed that if students feel they can succeed, they will perform well on math tasks (p. 175). Oakes found that what students perceive and experience in math and science "from the earliest grades through senior high school, will influence what they learn and whether they continue along the precollege mathematics and science pipeline (p. 189). In essence, early educational experiences effect future coursework and career choices.

In addition to reducing anxiety toward mathematics and building self-confidence, games can also promote curiosity and motivate students to learn math concepts. "With play, students learn by doing" (Henniger, 1987, p. 170).

Educational games have value from a practical point of view. A very practical reason for employing games in the classroom is that they can increase teaching time. When students are involved in game playing, valuable teaching time is freed up so that teachers can move about the room to observe and assist individual students. Rea and French (1975) concluded from their study that the use of number puzzles and enrichment activities greatly increased students' mathematical ability. The project duration was 25 days. Sixth graders comprised the two treatment groups and received their regular math each day in addition to 15 minutes of special activities. One group concentrated on mental activities, while the other worked with games or puzzles. The investigators took care that both groups studied the same mathematical concepts during the special activities time. Using SRA achievement test scores for pretests and
posttests, the authors summarized that the average growth rate for the mental math group was eight months; for the games and puzzles group, one full year.

NCTM (1975) has published an entire book of math games and puzzles to assist teachers in teaching mathematical concepts so that students can learn and have fun at the same time. The book is entitled *Games & Puzzles for Elementary and Middle School Mathematics*. The book includes a brief section on research regarding the positive effects of introducing games into mathematics classes. The games are presented according to the mathematical concepts they teach. Detailed descriptions of the games and rules include such topics as whole numbers, numeration, integers, rational numbers, number theory and patterns, geometry and measurement, reasoning and logic, and “multipurpose” games and puzzles.

We may not realize it, but the games that many people watch, play, and enjoy today are mathematical in nature. In Walt Disney’s movie, *Donald in Mathmagic Land*, chess is described as being a mathematical contest between two minds, as players must calculate their mathematical moves.

This movie also revealed that many games are played on geometric areas. Baseball is played on a diamond, with a sphere. The football field is a rectangle divided into yard lines. Basketball is played with spheres on a court containing circles and rectangles. Even the simple game of hopscotch has a playing area made up of squares. Billiards, a game played with spheres, is played on an area divided into two squares. The diamond markings are used to help calculate mathematical strategies, as players must attempt to hit three cushions before hitting the final ball.
Isaac Asimov (1964) has written a number of books that capture one’s curiosity and take on a creative and playful attitude toward mathematics. In his book, *Quick and Easy Math*, which is written for students, Isaac teaches students to train their memories for mental math tricks. He tells students to make a daily exercise of mental math for even “mental marvels” lose their ability without practice (p. 2). Asimov explained that everyday calculations “take up unnecessary time” (p.3) He indicated that with mental math, life can be made easier and time and errors can be saved. His book allows students to experiment, estimate, and see the patterns in our number system, to play, create, and enhance curiosity about mathematics. This is exactly the way NCTM (1989a) wants children to explore and experience mathematics - as a “useful, exciting, and creative area of study that can be appreciated and enjoyed by all students . . . “ (p. 65). By approaching mathematics in this manner, students can experience math as relevant, and a part of their everyday lives.

*Asimov on Numbers* (1977) again takes a playful and curious approach to mathematics. The book contains a series of Asimov’s essays, which all appeared in *The Magazine of Fantasy and Science Fiction*. He blends history and facts with fascination and admits he has a “mad passion for large numbers” (p.44). In one of his essays, he shared that in ancient history large numbers were not needed. He revealed that “million,” the Italian word for “a thousand-thousand,” had not been invented until the Middle Ages (p. 60). Asimov’s playful illustrations of patterns in numbers which appear across the universe and time would intrigue even the most nonmathematical person. This book makes the
mathematical connections between numbers and measurement, the calendar, biology, astronomy and the earth.

A third book by Asimov (1983), entitled *The Measure of the Universe*, again invokes one's curiosity and excitement about mathematics and its relationship to science, by providing fascinating information and playfully measuring length, area, volume, mass, density, pressure, time, speed and temperature across the universe.

There are a variety of games presently on the market that claim to develop problem-solving abilities in students. The Pentathlon Institute in Indianapolis offers sets of mathematical games to help teach logic and spatial reasoning for students in grades K-7. Sets containing five games each can be purchased by grade levels K/1, 2/3, 4/5 and 6/7. In addition to playing the games, which are played one on one, students can enter regional tournaments which take place in the spring of each year.

There are a myriad of games available through Dale Seymour Publications and Creative Publications which claim to promote problem-solving abilities and critical thinking in students. Manipulatives, specific units, teacher resource books, and student centers can be ordered from these and a multitude of other sources (catalogs, teacher centers, etc.) available to teachers. The software market has exploded with new games, puzzles and simulations - all claiming to nurture and develop critical thinking and problem-solving ability in our young.

Educators feel that many of these games and software packages are successful in assisting teachers with the teaching of problem solving and critical
thinking. Though there is little data to support their use, we have some intuitive notion that games can positively effect learning.

**Statement of the Problem**

The purpose of this study was to determine whether employing mathematical card games in third grade math classes would help improve student achievement in mathematics as measured by seven items that comprised the pretest/posttest. Items on this instrument were selected from the 1986 National Assessment for Educational Progress. (See Appendix A).

It was expected that students of teachers who implemented the MCIP card games in their math classes would have significantly higher gains in math achievement than those in control classes. In addition, it was anticipated that use of the MCIP card games would facilitate the introduction and understanding of mathematical concepts before they would normally be introduced at the third grade level.

As there is little research concerning the power of employing mathematical games to teach math concepts and analyzing their relationship to student achievement, this study has significance from both a theoretical and practical standpoint.

**Limitations**

All research studies have limitations of some sort. One limitation of this study was the voluntary nature of the population. Teachers who volunteered were given the choice for their assignment to either the control or treatment
group. However, this is a general limitation of all staff development research, as in order for staff development to be effective, teachers must be given the option to volunteer.

Another limitation was that only one school district was included for the study. The population was homogeneous and consisted of white, middle-class, suburban children. Since this was an initial investigation of the card games, in order for the treatment to be monitored effectively, a sample consisting of four treatment and four control groups was manageable. In addition, these card games have been used throughout the metropolitan area of Chicago. There is no reason to believe that they would not work in other school districts and populations.
CHAPTER II

REVIEW OF THE RELATED LITERATURE

Introduction

With the growing concern about the inadequacy of present mathematics instruction in our country, educators need to analyze current programs and make change in order that their students' needs can be better met. No two school districts are the same, and each district must recognize its own special needs to help guide reform.

The card games proposed in this study were implemented in the classroom with the intent of endorsing the standards set by NCTM and improving mathematics achievement and problem-solving abilities in third grade children. As indicated in Chapter I, these card games support many of the standards set by NCTM.

The information presented in the literature review was obtained through manual methods and computer searches. Topics investigated in this chapter focused on game theory, the instructional level of games, studies investigating the cognitive effects of implementing games in the classroom, student attitudes toward mathematics, problem solving, effective teaching of mathematics, and effective means of implementing staff development to implement change.
The Power of Play

How can students be motivated to learn problem-solving strategies that will help them in real-life situations? To assist students in gaining self-confidence in math, how can we promote interest in mathematics and reduce math anxiety?

Henniger (1987) stressed that play provides a stimulating atmosphere for learning. Through play, risks are minimized, thus opening "... the door for creative options" (p. 168). In addition, curiosity is enhanced through play. "The willingness to engage in divergent thinking" is also heightened through play (p.170). Children guess and test their options and create new strategies to help them solve their problems through play.

Henniger stressed that as play is a process-oriented activity, the fear of failure is reduced and self-confidence is boosted. Self-confidence is a motivating factor and allows a child to explore further. In play, students learn by doing and problem solving becomes fun.

Frank and Theresa Caplan in their book entitled, The Power of Play (1973), stressed the importance of the role of play in learning. "Play is the child's most dynamic manner of learning... Children do not play in a mental vacuum... They use and test all their ideas as they play" (p. 88). The authors added that the meaning of education is not just memory and recall, but the "laying down of such traits as creativity, the courage to try the unknown, wholesome self-image, self confidence, and inner discipline and drive..." (p.88).
The Caplans believed that once a child leaves the play environment of the kindergarten classroom and enters the first grade, a dramatic change occurs. The child is no longer free to play with academic ideas; thus he finds a more restrictive academic environment.

Learning and self-direction inevitably falter in such a rigidly structured environment. From his sixth through ninth years, the period when a child can make the greatest advance in academic skills, he can lose his interest in learning to learn because he is no longer allowed to explore challenging subject matter at his own direction and pace.

The Caplans cited studies of Head Start children who lost their advantage in early grades because they could not adjust to the "demanding curriculum imposed on them" (p.125). "Unless a play element is introduced to academics, unless a child gets more actively involved in his studies, unless there is greater manipulation, experimentation and discovery, academic interest withers away" (p. 126).

Play can generate interest and problem solving. A child is motivated to solve problems and develops the will power to persevere through play. "It is this vital will power that is missing in the academically and socially disadvantaged child" (p.113).

The Caplans said that children learn well only when they can manipulate objects (concrete level); then they can move on to more abstract learning. "Children generally distrust abstractions that are not arrived at through their own manipulation" (p. 126). Manipulatives motivate children and arouse their curiosity.

In a play and discovery setting there are no right or wrong answers to a finite number of questions. When children are in control of their own
learning they are not so much concerned with ‘right’ answers as they are with asking the right questions about the setting they are studying. The teacher joins in the quest, regarding herself not as an oracle, but as a fellow seeker.

(Caplan & Caplan, 1973, p. 134)

The Caplans believed that games, through their use of analytical and intuitive thinking, are effective in developing problem-solving abilities. They added that losing an educational game does not upset children as much as receiving a low or failing grade.

Play is a vital learning process. It provides the subject matter for activity, thinking and learning. The play element gives energy and motivation to learning. It is the freedom to experiment that spurs learning. Whether the play is with concrete objects or purely mental, there is always some plan in a play activity, and the end result is almost always likely to be the acquisition of satisfaction and some insight. . . Play, like nothing else, has the power to infuse learning with dynamic purpose.

(Caplan & Caplan, 1973, p. 138)

After a student learns the rules of play, he has to make judgments and act. Information needs to be assimilated in order to compete effectively and enjoy the game. The Caplans summarized that any game provides a series of interrelated actions that build up into a structure that only facilitates achieving the game’s goal, but also becomes the framework for retaining and using information. An educational game can structure human actions in the social sciences, the humanities, and mathematics.

(p. 135)

The Caplans described that all true learning goes through five stages. First there is a playing around period. Enriched materials allow free play to turn into “purposeful” games which lead to “higher awareness and interest” (p.145). The second stage is described as an intermediate, more structured stage of play and learning. The third stage leads to a child’s desire to use his ideas in different situations. This use of the child’s insight “through analysis and practice will firmly
anchor a child's learning" (p. 14). By the fourth stage, the child has a wealth of concepts that are well established and can be employed at will. Finally, at stage five, the child has concepts that can be defined by words and/or symbols.

Games have long been used in math to reinforce concepts and basic skills, but the power of using games to teach mathematical concepts has yet to be explored.

A very limited amount of research has been conducted on the effects of mathematical games on learning and achievement. Harvey and Bright (1985) regarded games as being effective in helping children learn mathematics. They defined mathematical thinking as "thinking intended to solve problems using mathematical knowledge, skills, and techniques" (p.23). They added that this type of thinking is often convergent and problems that are being solved may not necessarily be mathematical ones, though knowledge of math is useful in their solutions. In this manner, they believed the idea of mathematical thinking and playing games might be at odds with each other. However, using math games for only drill and practice, limited the power of play. They indicated that playing mathematical games can help students learn higher-level skills. Games can be effective before (preinstruction), during (coinstruction), and following mastery instruction (postinstruction). Their article included descriptions of mathematical games to be taught at each stage of instruction. All of these games required higher level thinking.

William Kraus (1982) discovered in his study that students used a variety of problem solving heuristics when playing the mathematical computer game, Nim. Working backwards, trial and error, finding patterns, reviewing previous
work, using a related problem, using pictorial representations, and employing subgoals were a number of strategies engaged by the students he observed. Kraus summarized that

since it has been shown that problem solving and the playing of certain games involving mathematics are related, continued research in the area is needed with the goal of effectively incorporating the use of games in instruction in problem solving.

(p. 181)

**Instructional Level of Games**

Bright, Harvey and Wheeler (1985) conducted a series of eleven studies to determine the achievement effects of mathematical games. They believed that the instructional level of a game is determined by the students who play the game. A game is played at the pre-instructional level if students have not received prior instruction regarding the instructional objectives of the game. The mathematical concepts are taught to students only through play of the particular game.

A game is played at the post-instructional level if students had learned the mathematical concepts prior to playing the game and had “received instruction designed to produce mastery of the instructional objectives of the game” (Bright, Harvey, & Wheeler, 1985, p. 9).

At the co-instructional level of play, the game playing is a part of the instructional program which is developed to promote student mastery. “Thus, the instructional level of a game for a particular group of students can only be determined by knowing what those students have and have not been taught and
what they will be taught while they are playing the game (Bright, Harvey, & Wheeler, 1985, p. 9).

In addition to instructional levels, Bright et al. (1985) defined the taxonomic level of a game according to the six taxonomic levels defined by Bloom (1956): knowledge, comprehension, application, analysis, synthesis, and evaluation. “The taxonomic level of the game is the highest taxonomic use of the mathematics content of the game that a game player would need in order to play the game efficiently and well” (Bright et al., 1985, p. 10).

Since they believed it did not appear to be important in school mathematics programs, the investigators did not include the evaluation level of the taxonomy in their studies. In addition, the synthesis level was disregarded for all levels of instruction, as students would have been expected to have mastery level comprehension at the pre- or co-instructional levels. In addition, there was no testing instrument available to measure learning at this level. The analysis level was disregarded at the pre-instructional level of instruction, as students were not expected to operate at this level with success when games were the only means of instruction.

By combining both the instructional level and taxonomic level of a game, Bright et al. (1985) studied the effects of implementing games into the classroom setting. In addition to their research, a number of additional studies have been conducted which examine the cognitive effect of games at varying levels of instruction.
Pre-Instructional Research

Trimmer, 1978, Bright, Harvey & Wheeler, 1980a, 1983, and 1985, and Schoedler, 1981, investigated the effects of game playing at the pre-instructional level. Bright et al. (1985) conducted three studies at various taxonomic levels. In grades six and eight, the games were played at the knowledge level. Games at this level were fair/unfair games where students played a series of two mathematical games and decided which one of the two was fairer. Thirty-six students comprised the sample from northern Illinois for both grade levels. In another study, grades seven, eight, ten and eleven played games at the comprehension level. The students played Polyhedron Rummy, a game dealing with three-dimensional geometry. There were 109 seventh and eighth grade students included in this study from Missouri and 94 students at the tenth and eleventh grade levels. The third of these pre-instructional level studies regarded playing games at the application level for grades seven and nine. Students played Number Golf, which involved the concept of probability. The sample consisted of 69 students at grade seven and 77 students from grade nine in northern Illinois.

For each study, a pretest-posttest design was employed. In all three studies, games were played twice per week with eight gaming days. The games were played for twenty minutes on each gaming day. (For detailed information regarding the specific games, testing instruments, and methodology, consult Bright et al., 1985).

It was determined from the above three studies that games were strongly effective at the pre-instructional level, at the knowledge and comprehension
levels. This was not the case at the application level. Apparently, students need prior instruction in order to learn higher level material through a games-only approach. It was concluded that, at the lower taxonomic levels, games can teach effectively without other instruction.

Trimmer (1978) studied the cognitive effects of employing the game Mastermind, (Invicta Plastics, 1972, 1976) designed to teach logical reasoning. There were 150 students participating in the sample from grades 3, 5, 7, 9, and 11. A combination of a pretest-posttest and posttest-only design was used, with the study conducted in three phases. During the pretest, practice, and posttest, ten games were played and included in each phase. Data regarding all games played were recorded. An analysis of testing data and records of the game keeping disclosed that age and experience had significant effects on student achievement. Though Trimmer declared that Mastermind can be used to assess and improve reasoning skills, his evidence was not clearly stated.

Bright et al. (1980a) studied the cognitive effects of homogeneous and heterogeneous achievement grouping with mathematics concept and skill games. The concept games were pre-instructional in nature and the mathematics skills games were post-instructional. The sample consisted of 164 seventh graders from eight classes in a northwest Chicago suburb. Half of the students played probability concept games and the other half played a fractions skill game. Using pretest scores, students were grouped with two or three classmates with similar or different achievement. Students were grouped heterogeneously or homogeneously for both the probability and fractions games treatments. The groups played the games for twenty minutes, two times per
week, for four weeks. The groups remained the same for all game playing days. Teachers provided no instruction regarding probability or fractions throughout the treatment period.

In all groups, students made significant gains when comparing pre and posttest scores. An analysis of covariance with pretest as the covariate was run on posttest scores for each type of game to determine if the grouping of students had altered the learning effects of the games. Results revealed that grouping students heterogeneously or homogeneously by their ability had little to do with student learning.

Schoedler (1981) compared the active games approach to learning with the traditional academic approach. All second graders at an elementary school were ranked on the basis of their scores on the Delaware Assessment Test which was administered at the end of first grade. Using the rank orderings, strata of six children were created. Within each stratum, the students were randomly assigned to one of the six classrooms at the second grade level. During fifteen class periods, the six classes were assigned to one of three groups: the control group, the academic group, or the games group. The academic group implemented the Houghton Mifflin Modern School Mathematics Program for Second Grade. Lesson plans for the games approach included existing games or those created by the investigator. There were no manipulatives or other objects used in either of the learning approaches. The content tests were parallel forms of Test A and B that were developed by Houghton Mifflin Company and employed as pretest, posttests, and retention tests.
Both groups of students in the active games method showed more improvement than the academic groups, though the results were not statistically significant. However, it was determined by the investigator that the "overwhelming enthusiasm" displayed by the teachers and students in the games group should be reason enough to consider the active games approach as a "positive alternative" to the traditional methods of teaching mathematics (p.370).

Bright et al. (1983) examined the effects of Mastermind-Regular (Invicta Plastics, 1976) and Number Mastermind (Invicta Plastics, 1976) on logical reasoning. Students from rural and suburban middle socio-economic backgrounds in seven intact sixth-grade classes and eight intact eighth-grade classes comprised the sample. They were chosen from two elementary and two middle/junior high schools in northern Illinois and south central Wisconsin. Control classes were two classes randomly chosen from each grade level. The pretest and posttest was a 40-item multiple-choice logical reasoning test. A posttest consisting of items relating to the game content was administered to the treatment group. Students were ranked from pretest scores and assigned partners in each experimental classroom. They were randomly assigned a new partner for each week. Students were prescribed to use one of the two versions of Mastermind for the entire experiment. Students played the games for eight weeks, twice a week, for twenty minutes a day.

When comparing pretest and posttest scores, there were no significant treatment effects. The investigators concluded that Mastermind alone was not effective in teaching formal logical reasoning skills.
Co-Instructional Research

Games can be labeled as co-instructional if they are combined with other methods of instruction with the intent of producing mastery learning.


Bright et al. (1985) studied the cognitive effects of implementing co-instructional games at the knowledge, comprehension, application and analysis taxonomic levels. Students from these four studies were from northern Illinois and south central Wisconsin. Games were played for eight to fourteen days, twice a week, for twenty minutes a day. All used a pretest/posttest design. For each of these studies, there were two grade levels included, with two classes per grade. In each intact class, a control group of six students was selected at random. These students were assigned to play Mastermind, as the content of this game is not related to the instructional objectives of the experimental games. (For further information regarding the specific games, testing instruments, or methodology, consult Bright, Harvey and Wheeler, 1985).

The study regarding co-instructional games at the knowledge level included 92 students from grade seven and 208 from grade nine. Seventh graders played Decimal Shapes, which involved ordering decimals. Ninth
graders played Write-and Solve and had to write and solve linear equations. Students comprising the sample regarding co-instructional games at the comprehension level included 113 fifth graders and 102 seventh graders. Fifth graders played ORTIG, which involved ordering fractions. The seventh graders computed averages with Average Hands. There were 41 sixth graders, 107 seventh graders, and 49 ninth graders who participated in the study concerning co-instructional games at the application level. Sixth and seventh graders played Prime Plus, a game involving fraction and decimal percent equivalences, and ninth graders dealt with rational expressions when playing Steeplechase. At the analysis levels, 63 seventh graders and 31 tenth graders comprised the sample. The seventh graders played In ProPortion, a game involving ratio, and tenth graders played Property Spin, which involved learning about properties of plane figures.

From the above four studies, Bright et al. (1985) concluded that co-instructional games were not effective with knowledge level content. (This assumes that teachers focus on this level of content for mastery learning.) The investigators disclosed that when instruction is effective at the knowledge level, another instructional technique such as games is not likely to improve learning. They concluded that games that are at the same instructional level as the teacher’s instruction are not likely to benefit students.

Co-instructional games at the comprehension, application and analysis levels yielded positive results. At least one of the grade levels for each of the studies regarding these taxonomic levels produced positive effects, while the other produced neutral effects. The investigators disclosed that a game at a
higher taxonomic level than classroom instruction has the possibility of being effective as there is no classroom instruction at that level to compete with it. They further this idea by stating that if classroom instruction provides an adequate base for learning, students are capable of learning higher level content.

Allen et al. (1966) studied the ability of the game Wff 'N Proof, a game designed by Layman E. Allen, to promote abstract thinking and logic. The sample population was 57 junior and senior high school students in public schools in Burbank, California. Employed was a pretest-posttest design, which used the California Test of Mental Maturity, Junior High Level, 1957 S-Form and the Advanced Level 1957 S-Form as the evaluation instrument. The treatment group comprised 35 students enrolled in summer school at John Burroughs High School during the summer of 1963. Students in this group played Wff-N Proof for the 29 days of the summer session, five days a week for a period of 45 minutes to one hour each day. In the remaining hour of the two-hour class, students read and discussed the rules of the game, concepts introduced, and took periodic tests to evaluate student performance.

Students took tests only when they felt they were ready and could not progress to the next level of the game until they received 100 percent on the test for the level on which they were working. The game uses a dice-like set of cubes which have logical symbols printed on them and involves two, three, four or five players. The winner is the person who can correctly construct a logical system and a proof of a theorem in the system by rolling the cubes competitively.
The 22 students in the control group were enrolled in fall classes for 1963 and took the pre and post test during a six week interval. There were no high school students included in the control group. Therefore, when comparing the treatment group with the control group, only the 23 junior high students were included for the treatment group.

The investigators compared the mean change scores for the junior high experimental and control groups. For the non-language IQ score, the treatment group had a mean change at +17.3, and the control group’s mean change was +9.2. It was determined that while the control group had some positive change, the change in the experimental group “was significant above and beyond whatever ‘normal’ changes one could expect” (Allen et al., 1966, p. 23).

Wynroth (1970) studied whether young children could learn natural numbers more efficiently by playing competitive games than by traditional teaching methods. The treatment group included a kindergarten class and a first grade class. The control group was another kindergarten class and two first grade classes. The control group received the traditional math program implemented by the school district for their grade levels. The Metropolitan Readiness Test was administered as a pretest. The project was conducted over one school year. Children played variations of games with dice, dominos, and cards. A number of commercial games were also included. Students were not ability grouped during the game playing. Written work was presented to students only after several months of learning math concepts through game playing. Posttests, administered in June, included the Metropolitan Achievement Test, Primary II; Test 5, Arithmetic, and an exam consisting of 60 problems
covering course material, in addition to a word problem exam with 14 dictated questions. Both tests were developed by the investigator.

It was determined from the test results that the treatment group showed significant differences in favor of the games approach to learning. Students in the treatment group "averaged close to twice as many correct answers as the control group children" on the 60-item exam. The level of significance was reported as "far under .0005" (p.41). On the Metropolitan Achievement Test, the results were again in favor of the gaming group, at a .0005 level of significance. Wynroth noted that all of the students in the experimental group, including the "slow learners," scored "within the upper 50% of norm group scores" (p.44); this was not the case for the control group. Kindergarten treatment students were able to correctly answer almost twice as many word problems as the control students at this age level, with the reported level of significance at .001.

Wynroth (1970) concluded that the games approach to learning kept student interest and involvement in mathematics at a high level. In addition, students had a desire to learn and understand the games and problems, even if they were slow learners. He believed games helped students to develop "a great deal of confidence in their own ability to eventually succeed in mastering any concept placed before them" (p.47).

Ross (1970) studied the effects of using the game approach to teach educable mentally retarded (EMR) children basic number concepts and social skills. She revealed that most EMR children cannot benefit from play with normal children, as the level of play is usually too complex. She tested whether EMR children could be taught the intellectual and social skills necessary to being
accepted and enjoying group play. There were 40 EMR children in five special classes that comprised the sample. None were on medication that could effect their learning, and none had gross motor, sensory, or emotional defects. Their ages ranged from 53 to 119 months. Their I.Q.'s ranged from 51 to 79, as determined by the Stanford-Binet Intelligence Test, Form L-M. Using test scores for chronological age, I.Q. and mental age, the students were matched as closely as possible in pairs. One from each pair was randomly assigned to the treatment group and the other placed in the control. There were 20 students for both the control and the treatment groups.

The treatment group spent 100 minutes per week over a nine-month game program; the control group spent the same amount of time, using a traditional special-class number system. Students in the experimental group worked in small groups in an experimental room with a research assistant who had been specially trained regarding the procedures of the games. To get subjects' attention, excitement was the focus of the games. A number of the games included races, escape, disaster, or other forms of excitement that forced children to pay close attention to how the game was played. The different types of games were table search games, card games, guessing games, active racing games, and board games. Modeling procedures directed by the game controller and using an adult model prevented peer criticism.

Number knowledge and a test for general games skills were employed for the pre- and posttests. For the games skills, students were observed for twelve five-minute periods of play with three different games in three different groups of students. (For further information regarding the tests and methodology, consult
Ross, 1970.) The treatment group had higher scores on all measures of number concepts than the control group. In addition, the number of errors these students made while playing the games decreased over time. Though the subjects were very reluctant to play the games at the beginning of the project, they lost their reluctance by the second month in the game training program. In addition, teachers and parents reported that many of the students in the treatment group had begun to use quantitative terms for the first time during free play. Ross disclosed that these results revealed that the subjects were beginning to learn quantitative thinking ability. There was no change over the nine-month period in the quantitative vocabulary of students in the control group.

It was noted that 14 of the students in the treatment group were playing games at home on a regular basis with normal siblings and neighborhood peers by the end of the fifth month.

Allen and Ross (1974) conducted a study to determine the effectiveness of the Instructional Mathematics Play (IMP) Kits and the game EQUATIONS. The EQUATIONS game promotes problem formulating and problem solving interactions among small groups of students. The IMP kits presents 21 of the mathematical ideas included in EQUATIONS. They consist of 16-page pamphlet-simulations of a computer playing EQUATIONS. The computer is programmed to play like a good teacher. Pretests and posttests included items that related to the 21 mathematical ideas presented in the kits.

The investigators sought to determine which combination of conditions best promoted student achievement: playing EQUATIONS alone, playing EQUATIONS in combination with two weeks of working with the IMP kits, playing
EQUATIONS combined with teacher instruction concerning the 21 mathematical ideas, receiving only traditional classroom instruction regarding the 21 ideas presented in the kit, or receiving regular classroom instruction without any special teaching of the contents of the IMP kit.

The 237 students comprising the sample in ten eighth grade mathematics classes were studied over a two-year period. It was concluded that a combination of playing EQUATIONS during the treatment and then giving intensive instruction with the IMP Kits for two weeks allowed students to better apply their mathematical ideas than any of the other four treatments, at "an extreme level of significance (.0001)." (p.3) Bright et al. (1985) warned, however, that in this study the investigators inappropriately used the student as the unit of analysis.

Freitag (1974) probed the effectiveness of a number of mathematical games, three of which he designed himself. The games included one which was similar to Bingo, a fraction game, and one involving algebraic expressions. There were six case studies conducted, including teachers and over 150 of their students. A pretest/posttest design was employed and game sessions were videotaped. The tape was analyzed on the basis of 35 variables, all of which fell into six categories: student tasks, model effects, roles of the teacher, roles of the students, game levels and norms. Though Freitag revealed that posttest scores were significantly higher than pretest scores, he made no mention of employing any statistical tests to determine this. The investigator concluded that the games enabled students to master mathematical concepts, motivated them to learn,
helped to develop student self-discipline, fostered cooperative and competitive spirit, and social acceptance.

Moyer (1974) investigated the effects of implementing a probability unit with concurrent dice games in six ninth grade general math classes. Both the unit, "Probability and Chance," and the dice games, Třrice Dice, were developed for the study. It was expected that by offering these two instructional methods simultaneously, student computational skills, mathematical reasoning and attitude toward mathematics would be enhanced.

The dice games were designed to apply knowledge of probability and to provide an opportunity for students to practice their computational skills. The method for determining total scores for the three dice games was varied so that five games were developed from the original three. The games for the treatment group were played for five weeks, twice weekly, with a different game introduced each week.

The control group consisted of six additional ninth grade math classes, who were instructed with the usual math curriculum materials. The two groups had no significant differences on pretest scores in attitude toward mathematics, computational skills, or mathematical reasoning.

Based on posttest scores, it was concluded that the treatment group did not have significant gains over the control group in regard to computational, attitude, or reasoning skills. However, using a posttest only measure, which comprised a test of knowledge of probability, the experimental group showed significant gains at the .05 level in comparison to the control group. The experimental group also showed significant improvement in arithmetic addition.
Weusi-Puryear (1975) studied treatment effects which included a simulated TIC-TAC-TOE game on the computer called GAMBO. There were 258 students in the San Francisco Bay Area who participated in the study. They ranged in age from eight to eleven years of age. Forty-minute game treatments composed a portion of the one-day field trips for summer school classes. Students were randomly assigned to one of three treatment groups all of which had equal numbers. There was one control group, another instructed with a computerized tutorial, and the third group's instruction comprised a combination of the tutorial in conjunction with GAMBO. Content for the two tutorial groups included addition for the eight- and nine-year-olds and multiplication for the ten- and eleven-year-olds. The same pretests and posttests were administered to all students. Students in the tutorial/games treatment group, proceeded to play the game if they correctly responded to the randomized exercises. These students had significant gains in achievement over students in the tutorial-only group. The gains occurred even though fewer exercises were completed by the game-playing students. For multiplication, the gain was significant at the .01 level; for addition, at the .05 level.

Kennedy and Newman (1976) explored the ways games affected the development of analytical thinking and problem solving skills in children in grades kindergarten through second grade. The study was located in a game center at the Southwest Educational Development Laboratory in Austin, Texas. The center contains about forty commercial games that were chosen for their ability to promote skills based on Guilford's Structure of the Intellect (SOI) model.
The game component was one part of the Thinking and Reasoning Program designed to develop independent problem solving skills in children. The remaining two parts of the program were a lessons component and a teacher training component. The lessons were sequenced into four strands of activities especially created to promote analytical thinking in addition to fostering personality skills such as curiosity, persistence, and frustration toleration. Teachers were provided with strategies for teaching process awareness through the lessons and games in addition to management skills that fostered independent learning in children.

Six classrooms were included in this study which was the 1974-5 pilot test of the Thinking and Reasoning Program. Three served as the treatment group and three as the control group. Students in both groups were from multicultural backgrounds, similar academic abilities, sex, and ethnic distributions. The curricula of both groups were similar, with the Thinking and Reasoning Program taking place of social studies for the treatment group. During the 45 minutes of the Thinking and Reasoning class period, 15 to 20 minutes were spent in small-group lessons. Those not being taught played games from the game center. These games were selected for their ability to coincide with the four lesson sequences of the program. Those students in the control group had no special instruction with games and received, instead, the regular curricula.

A consultant familiar with Guilford’s SOI Model developed eight SOI activities to administer to both treatment and control groups in May of 1975. (For further information regarding the activities or methodology, consult Kennedy & Newman, 1976).
When an analysis of variance was performed between the treatment and control group scores on each of the SOI activities, on six of the eight, there were no statistically significant differences found between the two groups. However, the treatment group had "superior performance" over the control group on the Object Assembly and Picture Completion activities, at the .01 and <.01 levels of significance.

There were 48 randomly selected students, out of 856 middle schoolers, who scored 70 percent or less on a 50-item basic multiplication achievement test that represented the sample for the study by Generes (1977). Generes used games dealing with basic multiplication facts and algorithms to study the effectiveness of teams-games competition over interpersonal competition. The three treatment groups were a control group, a group playing a game on an individual competitive basis, and a group playing a game using team competition. The study, conducted over the summer, was two weeks in duration. The control group students were instructed in their regular one hour mathematics class. The two treatment groups played the game Multiball for an hour each day in addition to their one hour mathematics class. During this one hour gaming time, students spent 20 minutes reviewing the previous day's game and either independently or with a peer studied the basic multiplication facts they missed. The next 30 minutes were spent playing the game. The remaining 10 minutes of the gaming hour was spent recording game scores and giving general announcements.

Multiball is similar to football in that students gain more yardage when correctly answering more difficult cards. Total points for individuals and teams
were totalled each day. The posttest, which was the same as the pretest, was administered on the tenth day. (For further information regarding the game Multiball or the treatment and analysis, consult Generes, 1977). A two-way analysis of variance was employed to determine if any significant differences existed between posttest scores for the treatment groups and the control group. Though there were no significant differences between the two games treatment groups, it was concluded that the students who played games competitively on an individual basis had significantly higher scores than the control group. (The significance level was not reported).

Henry, 1974, Wolff, 1974, and Kincaid, 1976, found that games were not effective in regard to their cognitive effects. Henry (1974) explored the effectiveness of the games Equations and Tac-Tickle in improving student attitude toward mathematics, nonverbal cognitive abilities, and quantitative cognitive abilities. Three junior high schools, including 182 students from nine seventh-grade mathematics classes, comprised the sample. Three teachers were included in the study. Each taught one control class, one Equations treatment class, and one Tac-Tickle treatment class. The two experimental classes played games for half of the class period every other day for six weeks. Regular instruction was alternated with game-playing instruction. Students played the games for a minimum of seven hours during the treatment period. Based on pretest and posttest scores, (The Dutton Attitude Scale and two batteries of the Cognitive Abilities Test; CAT), Henry found no significant differences in attitude or cognitive ability scores between the control and two games treatment groups.
Parents were specially trained to implement mathematical games at home in the study by Kincaid (1976). Kincaid investigated whether the games would have any effects on children's attitude and achievement in mathematics. In addition, he proposed the parents' attitude toward mathematics would improve.

An experimental group which included a control-group design was employed. Parents of 52 second-graders, who volunteered to participate in the project, were randomly assigned to either the experimental or control group. The program teachers, elementary education majors with no previous teaching experience, helped parents construct the games and guided the instruction of their use at home at weekly meetings. Parents were instructed to become actively involved in game playing with their children at home. Pretests and posttests measured math achievement and attitude toward mathematics.

The investigator concluded that game playing did not have a significant effect on mathematics achievement. However, it did have a significant effect ($p < .0451$) on students for fostering a positive attitude toward mathematics. In addition, the treatment also had a significant positive effect on the attitude of parents toward mathematics, at the .0001 level.

**Post-Instructional Research**

Students have already received prior instruction, with the intention of producing mastery learning, when a game is played at this level. Bright et al., 1980b, 1980c, 1981, 1985, and Ricks, 1983 conducted studies at this level of instruction. Bright et al. (1985) studied post-instructional games at the knowledge, comprehension, application, and analysis levels. The studies were conducted in south central Wisconsin and northern Illinois. The games were
implemented twice weekly, twenty minutes a day, for approximately eight weeks. One of the substudies undertaken at the comprehension level (grade ten) ran for a period of only six weeks. The two substudies conducted at the analysis level ran for 12 and 14 weeks. A pretest-posttest design was employed to measure student achievement.

At the knowledge level, games comprising addition and subtraction of whole numbers (grade 5) and addition, subtraction and multiplication of decimals (grade 8) were implemented. (For further information regarding the games, pretests and posttests, treatment, or results, consult Bright, et al., 1985.) At the fifth grade level, 87 students comprised the sample, and at eighth grade, there were 58.

There were 74 sixth and 100 tenth grade students comprising the study undertaken at the comprehension level. Sixth grade games related to fraction representations, and the tenth grade games related to the geometrical concepts of angles and measurement.

At the application level, 45 eighth graders and 68 ninth graders were included in the study. Eighth grade games relating to fractions, decimal and percent equivalences were employed, and rational expressions were the concepts introduced with the ninth grade games.

At the analysis level, 27 eighth graders and 79 tenth graders were included in the study. Eighth graders played games dealing with ratio; tenth graders played geometric games dealing with properties of plane figures.

Bright et al. (1985) concluded from the four above studies that games at the post-instructional level were effective in teaching mathematical content at all
taxonomic levels. The investigators believed that games are more effective at this level, rather than at the pre- or co-instructional levels, because students have already been instructed with the intention of producing subject mastery. Further, games at the comprehension level "are apparently effective in expanding fundamental knowledge level information that students have acquired to a more sophisticated taxonomic level" (p.121). At the application and analysis levels, it was revealed that games are effective when students have a broad enough base of knowledge of the particular instructional objectives that they can progress at higher taxonomic levels. However, the investigators warned that this conclusion needs further exploration.

Based on posttest scores, it was also revealed that at the knowledge and comprehension content levels, post-instructional games were effective at the higher grade levels (Grade 8 versus grade 5 and Grade 10 versus Grade 6). At the application and analysis levels, games were effective at lower grade levels (Grade 8 versus Grade 9, and Grade 8 versus Grade 10). The investigators' assumptions for the above conclusions were that secondary school teachers spend less time on materials at the knowledge and comprehension levels, as they assume students have mastered content at these levels. They presume that since mathematical content at the application and analysis levels is more difficult to learn, more time is spent teaching at these levels. To contrast, elementary teachers focus lessons at the knowledge and comprehension levels, which they believe are most difficult for their students. Since games are not as effective at the levels where instruction occurs and more effective at the levels where instruction is not being addressed in the classroom, Bright et al. (1985)
concluded that games implemented in their research “compensated for instructional deficiencies at the higher taxonomic levels” and also bridged the gap in the instruction that was provided by teachers (p.123).

Bright et al. (1980b) investigated the games MULTIG and DIVTIG (Romberg, et al., 1974) for their ability to retrain multiplication facts. There were 103 combined fifth and sixth graders sampled from four intact classes. The students were white and from middle socioeconomic families. The pretest/posttest instrument was a five-minute speed test of all the 100 basic multiplication facts. Two of the four classes were assigned the game MULTIG; the remaining two played DIVTIG. Games were played in 14 sessions for a period of 15 minutes. Students formed their own groups of three or four when assigned to play the games. Intervals between game playing sessions varied from six to 20 instructional days. During the duration of the treatment, there was no instruction regarding multiplication facts other than what was provided by the games. The study began on September 8, 1977, and the last day for game playing was April 11, 1978. The posttest was administered on May 25, 1978. The study included a total of 234 minutes for game playing and administering tests.

Bright et al. (1980b) concluded that games were an effective way to maintain skills. Using t tests to compare pretest and posttest scores, it was concluded that the differences were significant at the .001 level. In addition, in comparing pretest and posttest scores, the investigators reported a “dramatic increase” (196%) in the number of students scoring at least 90 percent. The investigators noted, however, that the study made no attempt to compare the
effects of the games with other treatments, such as daily instruction in mathematics during the school year.

Skill and concept games were employed to determine the effects of game characteristics with learner interactions in the study by Bright et al. (1980c). The investigators observed in previous studies that the amount of student verbalization during game time was greater than what was observed during traditional mathematics instruction. These observers noted the nature of the conversations and whether they were related to the game, to scoring or game strategy, or to matters that did not apply to the game playing. It was expected that record-keeping tasks and characteristics of games would differ for concept and skills games. Therefore, both kinds of games were employed. Remainder Game, MULTIG, My Number-Your Number, Moon Shot, Get to 999 First, and Shapescrabble were taken from Developing Mathematical Processes (DMP).

The study was conducted from September, 1977, through March, 1978 in Rochelle, Illinois, and MacFarland, Wisconsin. Approximately 115 students across grades three through six were included. Small groups of fourth through sixth grade students from Wisconsin played MULTIG while being audiotaped. It was revealed that, though students verbalized continuously during the game playing, the topic of their conversations was not always math. Students from Rochelle, in grades three and four, played Shapescrabble or Remainder Game for twenty-minute sessions. It was noted that in this school students were not conversing during the playing sessions. When an interview was held in January, it was determined that students were conversing more.
An intensive treatment phase lasting five weeks took place at the school in Rochelle and included 26 students who were videotaped on four occasions as they played all four games in groups of three or four. In each of the videotaped sessions, the game characteristics were altered by the following variables: team play versus individual play; methods for recording information (written, oral or no recording); means for calculating answers (paper and pencil, mental, calculator). These characteristics, or constraints, were changed with each round of the games. Most students played more than one combination. Students were asked the reasons for their game strategies at the end of each session.

It was concluded from analyzing the taped sessions that skill games promote player interactions more than concept games, though conversation related either to stating an answer or repeating a fact. The verbalizations not dealing with mathematics usually centered on computing a score or placing a playing piece. There was more verbalization in team play versus individual play, though the bulk of the conversation concerned who was to take the next turn rather than the math content of the game. It was also determined that when students use hand calculators to compute their facts, playing time was considerably slower.

To determine the cognitive effects of changing game characteristics, 88 students, comprising two fourth-grade and two fifth-grade classes, were studied at another school in Rochelle, Illinois, over a twelve-day period. Bright et al. (1980c) sought to determine the effects of student achievement if instructional objectives were included in the rules of a game, if recording information in the written form made a difference, and if altering information from which students...
could choose would effect their math achievement. Variations of the skill games included using a game board or pair of dice during the game play that allowed students to choose a two-digit number. Students either did not record answers or recorded computations and numbers required for a game round. Either the score was unrelated to the instructional objective of the rules of the game or it was dependent on answers provided by the student. Pretests and posttests were administered to determine student achievement in mathematics.

To determine achievement, t tests measured learning within each group. ANOVA measured the effects of the different treatments. It was concluded that changing game characteristics, or constraints, had no effect on student achievement at the post-instructional level of play.

Bright et al. (1981) conducted another study regarding the cognitive effects of varying game constraints with the game Order Out. Variations of the game included the use of manipulative fraction bars, representations of the bars in picture form, and removing fraction bars or their representations from the game altogether. The investigation was conducted during the spring of 1977. There were 85 students in four intact fifth grade classes and 177 students in eight intact seventh grade classes included for the sample. Students played variations of the game twice a week for twenty minutes a session over a five week period. Students ordered pairs of proper fractions for the 40-item pre- and posttests.

Teachers offered no instruction that related to common fractions during the course of the study. When t tests were employed to determine the effectiveness of games in improving student achievement of ordering fractions,
each treatment proved to be significant at the .001, or .01 level. To determine whether one treatment proved to be more effective than the other, an analysis of covariance was applied to the posttest scores. There were no significant differences between treatments. It was, therefore, concluded that though Order Out was effective in improving students' ability to order fractions, varying the constraints of the game had no effect on student achievement.

Ricks (1983) studied the effects of the game Equations on Math achievement of 130 seventh and eighth grade students. He concluded that, though there were no significant differences in achievement between the experimental and control classes, females in the experimental groups did significantly better than males in relation to achievement.

Further exploration of games and their effect on mathematics achievement needs to be conducted so that educators can make the best use of games which are incorporated into present mathematics curricula.

**Student Attitude Toward Mathematics**

In NCTM's efforts to implement the Standards, math needs to be viewed as a "helping discipline, not as a subject that students view negatively" (Dossey, 1989, p. 22). Though students come to school early in life with a love for mathematics and natural curiosity about the subject, their interest in and enjoyment of math declines as they progress through school.

A 1988 international assessment of mathematics and science, *A World of Differences*, reported that about 65 to 85 percent of all 13-year-old students surveyed in the twelve populations agreed they liked mathematics. However,
those students were higher achievers than the ones who indicated they did not like math (Lapointe et al., 1989, pp. 24-25).

While only 23 percent of the Korean students, the number one performers in all twelve populations, felt that they were good at mathematics, two-thirds of the American students agreed with this statement, despite the fact they were rated last in math proficiency (pp. 24-25).

In the NAEP report regarding the 1986 National Assessment nearly half the students in grades seven and eleven see math as mostly memorizing. More than 80% of the seventh and eleventh graders saw math as a “rule bound” subject (Dossey et al., 1988, p. 101). In addition, the report disclosed that “students’ general disposition toward math is positively related to their proficiency in the subject” (Dossey et al., 1988, p. 105). It was also disclosed that both confidence and enjoyment of mathematics seemed to decline as students got older. Though most students seemed to understand how math was used in everyday life, less than half of the students felt they would have a job that required a knowledge of mathematics.

Though most third graders felt confident of their mathematical abilities, less than half the students wanted mathematics to be a part of their future work lives. These results were consistent across race, gender and ethnic groups (Dossey, et al., 1988).

Seventh graders viewed mathematics slightly less positively than the third graders, but 55% reported they enjoyed mathematics, as opposed to 60% of the third graders.
By eleventh grade, only one-half of the students reported they liked mathematics and were good at it. In addition, students at this age viewed mathematics as more difficult than did seventh graders. While 51% of the seventh graders felt math was easy, only 40% of the eleventh graders agreed with this statement.

In the same study, half of all seventh and eleventh graders viewed math as "mostly memorizing." Students who did not perform as well in math (60%) agreed more readily to this conclusion, as opposed to 34% of upper-quartile students (Dossey et al., 1988).

More than 80 percent of both age groups felt math was a "rule-bound subject." Few agreed that discoveries are seldom made in mathematics (Dossey et al., pp. 101-103).

The myth that "What was good enough for me is good enough for my child," can no longer be tolerated, if students expect to succeed in the twenty-first century. As stated in Everybody Counts,

Today's world is more mathematical than yesterday's, and tomorrow's world will be more mathematical than today's . . . While arithmetic proficiency may have been 'good enough' for many in the middle of the century, anyone whose mathematical skills are limited to computation has little to offer today's society that is not done better by an inexpensive machine.

(National Research Council, 1989, p. 45)

Unfortunately, as children become socialized by school and society, they begin to view mathematics as a rigid system of externally dictated rules governed by standards of accuracy, speed and memory. Their view of mathematics shifts gradually from enthusiasm to apprehension, from confidence to fear. Eventually, most students leave mathematics under duress, convinced that only geniuses can learn it. Later, as parents, they pass this conviction on to their children. Some even become teachers and convey this attitude to their students.

(National Research Council, 1989, p. 44)
The ability of individuals to cope with mathematics wherever it arises in their later lives—whether as wage-earners, parents, or citizens—depends on the attitudes toward mathematics conveyed in school and college classes. Above all, mathematics curricula must avoid leaving a legacy of misunderstanding, apprehension, and fear. (National Research Council, 1989, p. 45)

Stephen Willoughby (1983) noted that many students leave high school with disability in and distaste for mathematics, making them neither able nor willing to use quantitative reasoning to solve everyday problems or to help earn a living. The “back-to-basics” movement, having misidentified what is really basic, is producing youngsters who are slightly better at skills that were of questionable value in the 19th century and will be of little value in the 21st century. (p. 46)

Hembree (1990), in a recent meta-analysis of 151 studies, discovered that mathematics anxiety has a relationship to poor performance on math achievement tests. As expected, math anxiety relates inversely to positive attitudes toward mathematics. Hembree found the variables that exhibited differential math anxiety levels were ability, school grade level, and undergraduate fields of study. He found preservice arithmetic teachers “especially prone to math anxiety” (p. 33). Grade levels one through twelve were included in the analysis. Results indicated that females had higher anxiety toward mathematics than males across all grade levels. However, Hembree found males were more anxious about math than females at the precollege level. He thought that, perhaps, females were more willing than males to admit their anxieties or that females may cope with their math anxiety better.

Sheila Tobias (1980) has studied why and how students, especially women, develop a dislike and anxiety toward mathematics. Since 1974 her interest has focused on women at the college level. She discovered that many
women at the college level tended to avoid any courses involving the mastery level of math that many of them had already attained in high school.

At the math clinic at Wesleyan University, students gave their math autobiographies to counselors. Tobias summarized from autobiographies by students who feared math and were certainly not disabled in the area that some or all of the following myths and factors influenced student attitudes and anxieties:

1) The myth that math aptitude is a gift rather than a set of skills that can be learned.

2) Mathematically able people can do math instantly, find mental arithmetic easy, and come up with the right answer in a short amount of time.

3) Math is only for men.

4) Girls are not given the same kinds of toys that develop problem solving, spatial visualization and building, in their youth, as boys.

5) The meanings of some words used in math have so many connotations, they seem confusing to verbally responsive students.

6) Some students never learn to "read" mathematics. They have not learned the special language of math, nor how to read math texts.

7) They have bad memories of mathematics in prior experiences in school.

   (Tobias, 1980, pp. 27-28)

Tobias added that "While the causes of mathematics avoidance and anxiety may vary by sex - girls having less pressure on them to remain in math and more of a self-image problem if they do - the cure for mathematics avoidance and mathematics anxiety may turn out to be the same for boys and girls" (p. 29).
Tobias cited a study by Casserly (1979) which revealed that in the high schools where at least 40 percent of the Advanced Placement math classes were filled with girls, mathematics was presented to all students as being important. In this situation, instructors worked to deliver interesting math programs, students were able to make up work they missed in math, and the community took pride in the school’s math achievement.

Tobias published a list of resources produced by the Institute for the Study of Anxiety in Learning. Directories, resource manual, student self-assessment kits, bibliographies of publications, films and videotapes are available to help educators reduce math anxiety in students.

Perhaps we are losing some of our best students in math because they become bored. Chapters that contain the most new materials in present texts (probability, statistics, geometry, pre-algebra) are “often skipped by teachers due to lack of time” (NCTM, 1989a, p. 66). Reduced attention should be given to fractions, long division, graphing by hand, paper and pencil algorithms. Increased emphasis should be given to geometry and measurement, probability and statistics, patterns and relationships, spatial reasoning, collecting data, estimation and mental arithmetic, genuine problems, 3-D geometry, graphical reasoning and discrete math (NCTM, 1989b).

All students need to be motivated and interested in mathematics early in life. Recent studies cited by Jeannie Oakes (1990) revealed that if students felt they could succeed, they performed well on math tasks (p. 175). Oakes disclosed that what students perceived and experienced in math and science in the earliest grades through secondary school influenced their course selections.
in college and, hence, their career choices (p. 189). However, Oakes added that even if some students did not enjoy math, they continued taking course work if they believed it would be helpful to them in their future careers (p. 173). We need to help foster positive experiences in math and science, along with the belief that a solid math background is vital in order to be a successful, informed adult.

Kloosterman’s study (1988) disclosed that students who are more self-confident achieved more in mathematics. The higher the confidence, the lower the math anxiety. Self-confidence helped motivate students to take risks in mathematical problem solving. Educators must, therefore, allow students to succeed at math in order to keep students interested and motivated to further their studies in the field.

The question of whether high and low ability students can succeed equally at mathematics must be posed. Capps’ (1969) study discovered that out of 188 fourth and sixth graders in 16 schools, emotional difficulties affected student achievement in mathematics. Low and even average intelligence combined with good work habits did not result in superior math achievement for most children. He found that those students who could not succeed in mathematics were of average intelligence. It is this population that Capps stated we must focus on.

Strong (1987) urged that teachers also need to build their confidence in mathematics. He suggested developing a variety of teacher support services. He felt teachers lacked the confidence to know which methods of teaching math were successful. In addition, he believed teachers were confused over new
materials and methods in the teaching of mathematics. Teachers need assistance in selecting materials. Past inservice sessions were not focused on classroom practice - the very thing these sessions should be concentrating on. Teachers cannot tackle this task alone, however. It will take the administration, parents, and the public to help them provide quality mathematics programs for our young. Extensive staff development is necessary to produce the change necessitated by the new strategies and curriculum NCTM has proposed.

Parents must work to help keep children interested and motivated in mathematics. The NAEP report (Dossey et al., 1988, p. 11) revealed that high school students whose parents encouraged taking mathematics courses had higher levels of education, and tended to exhibit higher mathematics proficiency than those who lacked this support at home.

Developing Problem-Solving Abilities

...Man's progress is measured in proportion to his ability to solve problems. Problem solving is the child's way of learning to use resources, both internal and external. Problem solving spurs his development as a person - his powers, self-respect, and self-confidence.

(Bingham, 1958, pp. 2, 3)

Children are capable of learning mathematics early in their lives. According to Piaget, there are different factors which affect the mental development of a child. One is a child's organic growth, how his nervous and endocrine systems mature. Another is the experience factor. The experiences a child has in his physical world relate to his mathematical thinking. "Social transgression" or the way the educational system transmits the use of knowledge by language is another factor. The "Equilibration" or "self-regulation" factor is
what Piaget felt was necessary to coordinate the above three (Copeland, 1974, pp. 30-31). Piaget described learning as an active process, involving one change being compensated for by a change in the opposite direction. It is, therefore, this equilibration that balances or accounts for learning to take place (Copeland, 1974).

In addition, knowledge, as defined by Piaget, is the "spontaneous process of total development learning" and involves the physiological, emotional and mental systems (Copeland, 1974, p. 38).

Piaget described the four stages of development for a child as being the sensory motor, pre-operational, concrete operational, and the formal operations stage. The sensory motor stage, which occurs from birth to eighteen months, finds the child at the preverbal stage of development. At the pre-operational stage, from eighteen to twenty-four months until seven years of age, is the "pre-symbol" stage. At this point brighter children may move one to two years earlier to the next stage of development, depending on their direct interaction with the environment. During the end of this stage, Piaget describes the move toward "semilogic," when a child begins to understand cause and effect relationships.

At the concrete operational stage, from seven to eleven or twelve years of age, the beginning of logico-mathematical thought occurs. Most of the time, all children in elementary school are at this stage. The child is thought to be "operational" in his thinking. He gets ideas from working with concrete objects. His learning is based on his observations and experiences with objects in his physical world. (Grouping, classifying, ordering, the idea of number, spatial operations, etc.)
Not until around age eleven or twelve does the formal operations stage occur. At this point, a child can reason with symbols or ideas, rather than concrete objects. (Copeland, 1974). Copeland (1974) cited Piaget's belief that, "To know an object is to act on it, modify it or transform it, and . . . to understand the way the object is constructed" (p. 35). Such an act is called an operation, which Piaget felt "is the essence of knowledge" (Copeland, 1974, p. 35). In other words, an operation is a mental action that reshapes or alters the object.

If we accept Piaget's theory, mathematics needs to be taught on a concrete level for all children (ages 5 - 12) throughout their elementary years in school.

Cruikshank (1988) supported the fact that children should use all five senses when making observations and inferences. As children gather information about the world around them, they need to describe what they are observing and inferring. He disclosed that language is a powerful tool for children and that they should be encouraged to talk to each other and the teacher while engaging in mathematical activities.

In addition, Cruikshank summarized that basic concepts from which children build their number concepts include observing, inferring, comparing, classifying, and sequencing. Mathematical concepts are developed as children recognize relationships between objects and sets. "These concepts are not exclusive to mathematics but are necessary in all subject matters" (p. 24).

Some of the concepts Cruikshank believed support early number ideas are conservation, one to one correspondence, classification, comparison, patterns and sequences (p. 56). He felt that some later number concepts to be
developed are place value and matching sets to numerals and number words. Cruikshank felt that it is possible for two- or three-year-olds to count up to ten, yet not know the meaning of the number six. However, he believed that some children may enter kindergarten with a clear understanding of what numbers are other than just words they recite in order.

Cruikshank urged that children should be provided with activities that encourage them to “seek and define problems, as well as to solve them . . . As children develop concepts and skills, they should use their problem solving abilities to construct knowledge for themselves” (p. 78).

How do children develop these problem solving abilities? George Polya (1973) felt that it is by imitation and practice that children learn how to solve problems. Observing and imitating others’ problem solving methods is necessary as is doing “problems by doing them” (p. 4). Polya stated that it is the teacher who must motivate and interest students, as well as provide ample opportunities for them to imitate and practice problem solving methods that will help children develop their own abilities. Polya felt that if good ideas are based on past experiences and formally acquired knowledge, good ideas can arise with little knowledge of the subject matter. If a student “makes silly blunders,” the problem most likely is that he has no desire to solve the problem or to understand it. It is up to the teacher to “stir up his curiosity” (p. 94).

A great discovery solves a great problem but there is a grain of discovery in the solution of any problem. . . .Your problem may be modest; but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery.

(Polya, 1973, p. V)
Polya described four steps in solving any mathematical problem. First, one must understand the problem - what it is asking, what data are given, and what the conditions are. In the second stage, connections between the data and the unknown must be made. Other problems may be considered here if an immediate connection cannot be made. The plan of solution is then obtained. In step three, the plan is carried out. Steps must be checked and it must be proven the the plan is correct. Last, the result must be checked. Other ways for obtaining an answer must be considered. If the process is successful, the question must be posed as to whether the plan can be applied to similar problems.

Polya believed that if students have difficulty in solving problems, they lack concentration or fail to carry out one of the above mentioned steps.

Putnam, Lampert, and Peterson (1990) agreed with Polya in that children “don’t absorb mathematical knowledge as it is presented, but impose their existing frameworks of knowledge to incorporate and invent new knowledge” (p. 89).

Bingham (1958) summarized the steps in successful problem solving. Children first need to identify the problem and then clarify it. After collecting data, they select and organize the information they have. They determine possible solutions, evaluate them, and put their solution into action. After assessing the quality of the solution, the entire process is evaluated.

Bingham added that “fears and shyness stifle creativity and the ability to do and participate” in problem solving (p.50). “A child ... must feel the responsibility, courage, and confidence to assume the initiative in overcoming
obstacles" (p.4). It was Bingham's belief that it takes perseverance, initiative, creativity, self-confidence, self acceptance, open-mindedness, responsibility, and the ability to overcome fears to be a successful problem solver. It is through opportunities to solve problems that a child "discovers and cultivates his abilities" (Bingham, 1958, p. 3).

Teachers need to provide the environment that promotes successful problem solving for children. In observing a group of 24 seventh and eighth grade teachers over a three year period, Grouws and Good (1989) discovered lessons that focused on problem solving as a topic did not occur frequently. When teachers were asked to teach a problem solving lesson they based most of the lesson on the textbook. This approach offered little challenge to the students, as teachers chose the sections dealing with verbal problems. They also found that teachers' use of time in problem solving lessons differed from teacher to teacher. Teachers spent little to most of the time discussing, illustrating, and explaining problems.

Grouws and Good believed that some teachers were able to foster growth in problem solving abilities successfully across classes and school years. Others were very unsuccessful. A relationship between a teacher's teaching style and student performance on problem solving tasks exits. Five of the most successful teachers they observed had 100 percent student gains in achievement scores. These gains would not have been predicted statistically. In addition, 75 percent of the classes of the five least successful teachers "gained less than would have been predicted from pretest scores" (Grouws and Good, 1989, pp. 35).
In a study by Nicholls, Cobb, Wood, Yackel, and Patashnick (1990), 102 students in six second grade classes were observed. In the treatment classes, verbal communication of mathematics and group problem-solving occurred. Students worked in pairs to solve problems, but whole-class discussion followed the solution of the problems.

At the end of the school year, students were surveyed to determine how they perceived the causes of their success and abilities in mathematics. While all classes felt that interest and effort caused success in mathematics, none of the other classes matched the motivation of the target classes. The target class believed their success in math was encouraged by their “attempts to understand mathematics” (Nicholls et al., p.119).

Sowder, Threadgill, Moyer, and Moyer (1986) studied 167 sixth graders in five schools. Students took a conceptual understanding test (CUT) which determined their ability to select operations for given mathematical problems and then enter the numbers needed to compute a solution. Students did not compute the answers. It was discovered that many of the students did not understand the basic meaning of the four operations. One quarter of the sixth graders had a limited understanding of multiplication or division.

It was suggested that teachers focus on the meaning of mathematics. Most curricula do not provide the language that is necessary to discuss operations. To foster this discussion, students can be asked to make up their own questions for written or pictured data. In addition, teachers need to use concrete materials in a variety of ways in order to teach mathematical concepts.
Sowder (1989) stated that most children up to junior high age, have adopted one or more immature strategies for problem solving. One of the strategies is coping. Students find the numbers, then and add or guess at the operation to use. Many have immature computational skills. They look at the size of the numbers, try all operations, and choose the most reasonable answer. In addition, students look for isolated key words or phrases to signal an operation. They decide whether the answer should be larger or smaller than the given number; if it is larger, they try to add and multiply before they choose an answer. If it is smaller, they try subtraction and division.

Sowder believed these immature strategies are employed by students as a result learning the textbook story problem solving strategies that are taught to develop understanding of operations. He urged teachers to routinely ask students for their reasons for choosing particular operations when solving problems, to model such reasoning in explaining to children how to decide on particular operations, and to use more multi-step problems with “attractive irrelevant” information (Sowder, 1989, p.26). In addition, he urged teachers to allow students to work in small groups to solve mathematical problems.

Klausmeir and Loughlin (1969) studied children of low, average, and high intelligence and compared the amount of time it took them to solve mathematical problems. Findings indicated that teachers need to focus more time on teaching students process, rather than arriving at solutions quickly. Students involved in this study solved mathematical problems in the same amount of time when measured in mean number of seconds. How they solved problems differed, however. When children of low ability arrived at a solution, they did not bother to
check through to see if their answer was correct or made sense. High ability
children rejected solutions until they arrived at a correct answer. They were able
to note and correct their mistakes independently.

Grouws and Good (1989) stressed that it is this process of problem
solving that must take over every aspect of school mathematics. They revealed
that the nature of problem solving lessons affects the immediate learning of
children and has long-term effects on the kinds of problems students can solve,
as well as the types of problems students are willing to attack and have an
interest in solving. Student interaction is necessary for this development to take
place.

Hitch (1990) related that when children can explain their reasoning, they
have a chance to get their thoughts and ideas together. Teaching math as
reasoning fosters more “appropriate and healthy beliefs about the subject”
(p.17). When children can see how concepts and procedures are related, they
will remember parts of the connected whole, rather than separate isolated facts.

Mumme and Shepherd (1990) felt that this open communication among
students promotes a comfortable environment for learning. It also assists the
teaching by allowing the teacher to gain insight into students’ thinking.

It has long been assumed that spatial reasoning skills directly affect one’s
ability to solve problems. Spatial skills may be defined as those mental skills
concerned with “understanding, manipulating, reorganizing, or interpreting
relationships visually” (Tatre, 1990). In a recent study by Tartre (1990) fifty-
seven tenth-grade students who scored high or low on a spatial orientation test
were asked to solve mathematical problems while being interviewed individually.
Results indicated that students with low spatial orientation were less flexible in solving problems on their own. Only ten percent could arrive at a solution for one problem with hints. Forty-one percent of the high spatially oriented students were able to solve a problem on their own.

The high spatially oriented students were also better able to estimate the approximate magnitude of an answer, in addition to being less likely to get stuck in an unproductive mind set. Those in the high spatial group said more often than those in the low group that they had previously solved similar problems. They could more often arrive at a correct solution when the visual framework was given.

**Effective Teaching of Mathematics**

Teachers of mathematics must be knowledgeable and proficient in the subject area in order to teach effectively. Bingham (1958) studied teacher knowledge of division in her analysis of nineteen prospective elementary and secondary teachers and discovered that, though many of them could produce the right answers, several could not. In addition, few of them could give mathematical explanations for the concepts and meaning of division when presented in three different contexts (division with fractions, division by zero, and division with algebraic equations). Bingham concluded that mathematical learning prior to college is not sufficient preparation for prospective teachers. In order for teachers to effectively teach math concepts so that students understand the reasons for their calculations, teachers need to have a command for mathematical concepts themselves.
In a study by Borko and Livingston (1989), expert and novice math teachers were compared in regard to planning and delivering lessons. The student teachers (novice teachers) were less efficient in planning lessons. They experienced problems when trying to respond to students' questions, if the students wandered from the "scripted" lesson plans (p.473). In addition, the novices did not plan beyond the next day. They had trouble making priorities about decisions regarding content coverage. They were not as effective as the expert teacher when delivering planned lessons. The experts not only planned more quickly and efficiently, but were better able to predict where students would have problems.

For six years Leinhardt (1986) studied the arithmetic teaching of seven expert elementary school teachers. She believed that there are three successive conditions for the effective teaching of mathematics. One is that teachers must determine the scope of what is to be covered over a certain period of time. Second, all of math time should be used on math; therefore, homework should be assigned to extend that time. Math lessons, routines and structures should be clear with a variety of demonstrations and examples. Third, expertise in the content area should be specific. Because this content knowledge is so significant, Leinhardt suggested that supervisors hold mini seminars regarding different topics presented across the discipline.

Carpenter, Fennema, Peterson, and Carey (1988) studied teacher understanding of children's thinking about mathematics, in addition to teacher knowledge of student thinking. Forty first grade teachers were included in the study which evaluated their knowledge of children's strategies for solving
addition and subtraction problems. The teachers concluded that student performance significantly correlated with teachers' ability to predict success. Student performance was not significantly correlated, however, with teachers' ability to predict the strategies students would employ. The study suggested that teachers focus on the processes students use to solve problems.

In a later study by Carpenter, Fennema, Peterson, Chiang and Loef (1989) twenty teachers in the treatment group participated in a month-long workshop where they studied a research-based analysis of children's development of problem-solving skills in addition and subtraction. Though instructional practices were not dictated, the teachers in this group "taught problem solving significantly more and number facts significantly less" than the twenty control teachers (p.499).

Students in the control classes were more likely to be given review work in addition to word problems that were solved individually at their seats. Students in the experimental group were more likely to solve problems in a whole-group setting.

The teachers in the experimental group had more knowledge of their students' problem-solving processes and listened to their students description of these processes significantly more than the control teachers. In addition, they encouraged their students to use a variety of problem-solving strategies. It was, therefore, determined, that teacher knowledge of research regarding children's thinking directly influenced teacher instruction and student achievement.

The study also determined that problem solving should be the central activity of mathematics instruction. In addition, teachers should build on
students' prior knowledge. In order to do so, they must allow students ample opportunity to communicate their reasoning and thinking about mathematical problem solving.

Walberg (1986) summarized that in order for students in the early grades to learn math more effectively, teachers need to use manipulatives in teaching mathematical concepts. Teaching students how to estimate is also important. Teachers need to set high expectations for their students. Involving parents in their children's learning also helps foster effective learning. Assigning homework can extend classroom learning and increase time on task.

Simon (1986) discussed the development of new or "under-used" teacher skills that are taught during a Summer Math inservice training program for teachers at Mount Holyoke College. The program is based on the belief that teachers need help in changing their role from the "lecture-demonstrator" to a "facilitator." In planning lessons that allow for active learning, Simon revealed that the roles of the teacher are to identify and prioritize what needs to be learned, distinguish between facts, procedures, and concepts, and organize the concepts hierarchically. What is to be learned should be divided into increments and then activities need to be developed to stimulate the concept. Simon added that when teachers implement the above process, they need to ask questions that promote student communication so that students reflect on and verbalize their thought processes. Subtasks need to be provided when needed and student understanding must be regularly evaluated.

"Once students learn to rely on procedures, they tend to give up on common sense" (Dossey et al., 1988, p. 67). Marilyn Burns (1986) stated that
"computation success often masks our failure as educators; we have not helped students develop higher-level cognitive skills and understanding that go beyond rote, step-by-step learning" (p.34). Burns added that learning what to do is easier than learning "what to do and why" (p. 37). Present textbooks tend to emphasize procedures. In addition, because teachers are accountable for their classes' performance on state exams, students are often taught what to do instead of why. Burns declared that a number of teachers do not know the difference between teaching "procedures" and teaching "mathematical reasoning" (p.37).

Burns disclosed that the purpose of teaching reasoning in mathematics is that when students understand why they do something, they can more easily apply what they have learned to new situations. When students know what procedures mean, they can remember them more easily. Finally, Burns related that learning to reason supports continued learning. Students gradually appreciate the meaning of mathematics and become successful in learning new information - all of which motivates them to learn more.

Allowing students to work in small groups encourages communication of mathematical ideas. Taylor (1989) warned, however, that effective cooperative learning demands extensive staff development. Support and involvement of the administration is important.

The NAEP report (Dossey et al., 1988) revealed some discouraging news about the infrequent use of cooperative learning in mathematics in our country. Almost no students at the three grade levels reported working problems in small groups, or doing reports or laboratory activities; instead sizable
proportions of students reported working problems independently either daily or weekly.

(p.67-68)

Good, Reys, Grouws, and Mulryan (1989) believed that student verbalization and understanding of mathematics can be heightened during small group instruction. They distinguished between "work" groups and "achievement" groups. In achievement groups, students are placed according to their ability level. Work groups comprise students of mixed ability and promote social as well as academic outcomes.

In a previous study by Good, Grouws, and Mason (under review) that was cited in the article, the authors observed thirty-three teachers from twenty-one schools. These teachers used either work or achievement groups on a regular basis. The study concluded that teachers who used work groups for part of the period assigned students interesting and challenging mathematical tasks which encouraged communication and the promotion of critical thinking skills.

Described in the study by Good et al. (1989) were fifteen teachers in nine elementary schools. Sixty-three lessons employing both achievement and working groups were script taped. The work groups proved to be more effective than the achievement groups in a number of ways. Students were more actively involved in mathematics in the work groups. They had been more exposed to mathematical activities and problems that promoted critical thinking than were achievement groups. There was more opportunity for peer interaction, as well as the opportunity for students to become exposed to more diverse and advanced mathematics concepts than the achievement groups.
The observations concluded that teachers who were observed seldom used lessons from the text. Several of them commented that they altered what was presented in the textbooks or used their own ideas instead because the text did not promote cooperative learning.

The authors warned, however, that there were a few disadvantages noted in the observation of the work groups. Often, there were inadequate curriculum materials provided for the teacher. Because the teachers often created their own activities, there was often discontinuity in the curriculum. Often the tasks were not group-oriented. Tasks were not well suited for group work when they did not expect students to work together in "exploratory behavior" (p. 59).

As a result of teachers allowing too little time for groups to work, some students or groups were unable to complete tasks. In other instances, some teachers allowed too much time. Thus, when students completed tasks, they engaged in "off-task" behavior (p. 59).

The authors concluded that assigning roles to students who worked in small groups, tended to be artificial. Students switched roles when they felt it necessary. A number of high-ability children controlled the group or preferred to work independently. In addition, there always seemed to be a number of students who remained passive in each observation.

Too many lessons that were observed lacked closure. It was suggested that teacher summary and whole-class discussion be held after each lesson.

NCTM (1989a) has urged educators to work toward the goal of making all children mathematically empowered for a technological society. Math should be something one does. The mathematics curriculum should be for all. It should
include a broad range of content in a variety of contexts. Deliberate connections should be made. Mathematics should be an active, constructive process with instruction based on real problems. Providing quality mathematics programs for all will ensure productive citizens in the next century.

NCTM has noted that ineffective methods for teaching mathematics are teaching by telling and rote memorization. Using routine worksheets, having students memorizing rules, learning that there is one method to arrive at one answer should be minimized in the teaching of mathematics.

**Implementing Effective Staff Development**

The kind of teaching that is envisioned by the Standards is in sharp contrast to what many teachers experienced as students themselves. Teachers need time and assistance to learn and develop new ways of delivering the mathematics curriculum. NCTM (1989b) related that:

This kind of teaching conflicts with some current patterns of teaching and learning. It requires that students be allowed to talk with their peers, to argue, to experiment, to invent and justify alternatives, and to be wrong. It also requires the teacher to step back from the role of being the dispenser of knowledge and the confirmer of right answers. For teachers to be able to change their role and the nature of their classroom environment, administrators and supervisors must expect, encourage, support, and reward the kind of teaching described in this set of standards. Because change is difficult and will take time, teachers must not be expected to respond simultaneously to several different calls for change or new demands.

(p.4)

How can the gap between theory and practice be bridged? Can innovations be properly implemented so that they will positively affect student learning? How can teachers be trained to be more effective so that students can
become empowered learners? Effective staff development programs can help to achieve this goal. The Mathematics Report Card, a report submitted by the National Association of Educational Progress (NAEP), indicated that the Southeast was the only region in our nation to show significant improvement in the mathematics achievement of all 9, 13, and 17-year-olds assessed. Great efforts have been made in this area of our country to move toward educational reform.

Enhanced teacher training programs, career incentives, expanded assessment programs, increased graduation requirements, strict monitoring of absenteeism, increased amounts of homework, and heightened citizen awareness all mark the movement toward academic excellence in the South. . . As the Southeast improves and the other regions remain relatively stable, the differences in performance levels among the regions are becoming increasingly negligible.

(Dossey et al., 1988, pp. 27-28)

Fullan (1990) proclaimed that it has been evident “for at least 15 years that staff development and successful innovation or improvement are intimately related” (p.3). Change means learning how to do something new. In order for that change to be successful, Fullan stated that staff development must be regarded as institutional development. He regarded the implementation process as a learning process. When implementation is linked to “specific innovations, staff development and implementation go hand in hand” (p.4).

Without effective staff development programs, teachers will not be able to change the way they teach mathematics. We cannot expect our students to become mathematically literate unless teachers receive the support and assistance necessary to implement change.
Joyce (1990) warned that though the best staff development programs focus on individual, school, and district needs, most programs involve only small percentages of staffs. Even when such programs are based on cautious needs assessments, most teachers do not take advantage of them. There needs to be a high incidence of collegiality among the faculty in order for staff development to be effective. Joyce related that, unfortunately, most school systems do not possess such an environment. In addition, the training that is provided by many districts is too weak to make any significant changes in the curriculum or technology of the system. As a result, Joyce stated that many leaders in the field of staff development are putting their efforts into changing the culture in the schools in order that innovations be implemented effectively.

Fullan (1990) related that successful staff development can have the unanticipated side effect of teacher collegiality. Good staff development allows the opportunity for teachers to share and interact with each other. Fullan warned, however, that the culture of any school is a powerful component. It is incapable of being influenced for any length of time by “single or passing projects - no matter how well designed” (p.12).

... Collegiality must be linked to norms of continuous improvement and experimentation in which teachers are constantly seeking and assessing potentially better practices inside and outside their own school ... commitment to improving student engagement and learning must be a pervasive value and concern.

(Fullan, 1990, p.17)

Further, he advised that in order for powerful change to take place, powerful strategies are needed. In this sense, rethinking and integration must take place at the individual, school, and district levels. He urged that staff
development be viewed as the informal and formal learning that one experiences during one's career. This view of "life-long" learning for all teachers must be applied and worked toward on a continuing basis (p.22).

Fullan proclaimed that it is the teacher "as learner" who becomes the link between school and classroom improvement. The components of classroom improvement described by Fullan are content, instructional strategies, instructional skills, and classroom management. Collegiality, shared purposes, continuous improvement and structure are the elements of-school improvement which he advocated. The teacher as a learner shares his or her responsibility with coworkers in order to help implement and promote the intended change.

Joyce and Showers (1988) indicated that a major purpose of any staff development program is to "ensure that all personnel are aware of the magnitude of the effects that can be achieved when innovations are used properly" (p.28).

Joyce and Showers (1988) revealed that there are six basic assumptions about human resource development. The first is that comprehensive resource-development systems should be created. The second is that student learning can be greatly enhanced as a result of human resource development. It must also be assumed that all teachers can learn. The norms of the school need to change if effective staff development is to be implemented. An effective system of preservice and inservice education will provide common knowledge and the skills to use it. Finally, what is taught, how it is taught, and the social environment of the school must be under continuous study by the teachers and administrators in order to make the school better (pp. 2-4).
Joyce and Showers believed that the goal of training is to enable people to acquire new knowledge and skills and transfer them to active classroom practice. Training should include theory, demonstrations, and practice with feedback. They discovered that when coaching is added to preliminary training which involves the above components, there is a large and dramatic increase in the transfer of learning. Coaching is essential if teachers are expected to continue to use the new ideas, materials, and teaching strategies presented to them in training. It is this transfer of learning into existing curriculum and behaviors that causes discomfort for any teacher. Practice helps, but the transfer of training is separate from the learning task itself (Joyce & Showers, 1988).

Coaching is characterized by being attached to the training, continuous and experimental in nature, and separate from supervision and evaluation. It provides a support system that teachers need in order to practice the training they received actively. For most teachers, "it requires 20 or 25 trials and the assistance of someone who can help . . . analyze the students' responses" in order to learn a new approach to teaching (Joyce & Showers, 1988, p.82).

Joyce and Showers (1988) attested that teachers need time "to watch each other work and time to talk . . . Coaching should be viewed as a "cyclic process," designed to extend training and provide support during change (p. 85). They discovered that coaching contributed to training in a number of ways. Teachers who were coached, in comparison to those who had not been coached, practiced new strategies more often and became more proficient at implementing new strategies at appropriate times. In addition, they had greater
“long-term retention of knowledge about and skill with strategies” they had learned (p.89). They were also more likely to introduce the new models of teaching to their students. Finally, coached teachers more fully understood the purposes and uses of the new strategies they learned when compared to teachers who had not been coached.

Cohesiveness and strong leadership in schools are necessary in order for training to be successful. Joyce and Showers affirmed that almost all teachers can master a wide range of teaching skills and strategies if the training provided is well-designed and the school climate “promotes cooperative study and practice” (p.70).

Joyce and Showers (1988) indicated that teachers not only need time to have numerous opportunities to practice new skills in order to master them, but must also realize that transferring the learning to “active practice” is extremely difficult. They disclosed that teachers must also be flexible when learning new behaviors. This flexibility in the learning process can be described as “a spirit of inquiry, a willingness to experiment with their own behavior, and an openness to evidence that alternatives have something to offer” (p.76).

Findings by Stallings (1989) indicated that teachers are more likely to change their behavior and continue to use new ideas if:

1) they become aware of the need for improvement;
2) they make a written commitment to try new ideas in their classroom the next day;
3) they modify workshop ideas to work in their classroom and school;
4) they try the ideas and evaluate the effects;
5) they observe in each other's classrooms and analyze their own data;

6) they report successes or failures to their group;

7) they discuss the problems and solutions regarding individual students and/or teaching subject matter;

8) they are given a wide variety of approaches; modeling, simulations, observations, critiquing video tapes, presenting at professional meetings;

(Stallings, 1989, pp. 3-4)

As research has indicated, teachers can and will change the way they teach. However, they will only do so if they see the need for change, have a supportive environment, and receive effective and on-going staff development. School districts cannot do this alone, however. Effective staff development and training programs are expensive and time consuming to implement.

The Need for Further Research

Stephen Willoughby (1983) disclosed that unless the federal government is willing to help our children become mathematically literate, there is no hope for reforming mathematics education. He said that local school districts cannot take the burden of funding such reform.

...There is no hope that local property owners and state taxpayers are going to vote the necessary funds to match the major national commitment that has been made by virtually every other developed country in the world - notably the Soviet Union and Japan. If the federal government can provide matching funds for highways, surely it can do so for education.

(p. 48)

Additional research needs to be conducted to promote changes in programs, processes, progress and products in mathematics education. Publishers, parents, partners in business and industry, and educators all must work together to promote change in the teaching of mathematics. (Frye, 1990)
The Research Advisory Committee of NCTM (1990) encourages any research to promote productive reform in the field of mathematics. NCTM has stated that we need to study the effects of the standards on the teaching and learning of mathematics. In addition, curriculum and evaluation materials are needed to exemplify the recommendations set by the Standards.

The committee added that assessments of how students learn need to be undertaken. The effects of changes in curriculum materials need to be studied. In addition, investigations regarding mathematics as communication, both oral and written, in relation to mathematics learning need to be conducted. Research is needed in order to learn about student beliefs regarding mathematics and the effects of the interaction of technology with other instructional techniques.

Significance of the Study

The exploration of how mathematical card games could promote the Standards was conducted in the present study.

Joyce and Showers (1988) revealed that during the last twenty-five years there has been an explosion of educational research that could be applied to practice, though little has been incorporated into staff development programs (p. 27). They claimed a major part or focus of any teacher training program should be based on how students can benefit (p. 28).

A small amount of literature is attainable regarding the effects of mathematical games on student achievement in mathematics. The results of the study will add to the field of interest concerning the power of play.
A major component of incorporating the MCIP card games into the third grade curriculum, was staff development. The goal of the study was to put theory into practice. In order for change to occur, teachers had to learn how to apply theory and learning to daily life situations. Their students had to undergo the process as well. The mathematical concepts that they learned through the use of card games were applied to a variety of situations in the classroom and outside of school.

Because there is such a large gap between the teaching of mathematics and learning, (NCTM, 1989b) one of the goals of the training was to assist teachers in transferring the new skills and information they acquired to active classroom practice.

The workshops planned for the project modeled effective staff development research. Theory was introduced and modeling of desired teacher behaviors was included. Teachers were given the opportunity to practice what was presented in a safe environment. Peer coaching by the investigator and fellow third grade teachers enhanced support for implementation of the new methods of teaching. In addition, district administrators were in favor of the project and were willing to help in any way.

By providing effective staff development to teachers in a supportive atmosphere, the NCTM Standards were capable of being actively transferred to the classroom by use of the MCIP card games. In addition, gains in student motivation, interest, and mathematical ability could be monitored. The gap between theory and practice could possibly be narrowed through results from this study.
The project provided a fresh, innovative approach for making mathematics alive, active, and interesting, in hopes that ALL students would become the mathematically literate adults they are capable of being. It was expected that the MCIP card games could provide an economical and efficient means for implementing the NCTM Standards in the classroom.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to determine whether implementing the MCIP card games in third grade math classes would have a positive effect on student achievement in mathematics. This chapter presents the methodology used in this research. In the first section, the population and selection of the sample will be discussed. In section two, the instruments employed during the study will be examined. Section three describes the treatment. The procedure for collecting data will be discussed in section four. Finally, the design and statistical procedures will be presented in section five.

Population and Selection of Sample

The study was conducted in a Midwest suburban school district from September to November of 1990. The district is comprised of white students from a middle to upper-middle class socioeconomic group. The school district has an enrollment of approximately 2,200 students. There are four elementary schools and one junior high.
Approximately 200 students comprised the sample in this study. Teachers volunteered to participate in the project for either the treatment or control group. They were assigned the treatment group of their choice. There were originally nine intact groups; four treatment and five control groups. The purpose for the additional control group was to insure homogeneity for both control and treatment groups. The additional classroom provided a larger pool of students from which to draw students. As students in this class had achievement test scores well below those of the other third graders included in the study, control group number one was eventually dropped.

The grade two achievement test scores from the March 1990, Stanford Achievement Tests, Form E, were analyzed. Individual student scores from the Otis Lennon (SAI), Reading Comprehension, Concepts of Numbers, and Math Applications portions of the SAT were included in the analysis. Nine of the students were new to the district and did not have achievement test scores available but were included in the study for having scores for both the pretest and posttest. Group means for the achievement test scores were calculated on the basis of available scores and did not include the students whose scores were not obtainable. The mean for each subtest was calculated according to the National Percentile scores recorded for each student. The last figure calculated was total number of problems solved correctly on the pretest. The results from the four experimental and control classes included for the study are indicated in Table 1. Originally, 181 students were administered the pretest during the week of September 17, 1990. A number of students were either not present for the posttest or had moved. There were 171 students who were administered both
pretests and posttests for the study. The control class which was dropped contained 11 students, which left the sample population at 160. Class means for achievement tests were based on scores from 151 students, as achievement test scores were not available for nine students.

Control and treatment groups were compared according to student ability. Student Ability Index or SAI (Otis-Lennon ability score), Reading Comprehension, Concepts of Numbers, and Math Application scores were analyzed from the 1990 March Stanford Achievement Tests, Form E.

All control classes were located in the largest elementary school in the district. This school had approximately twice the student population as the other two schools from which experimental groups were included for the study.

### TABLE 1

<table>
<thead>
<tr>
<th>ACHIEVEMENT AND PRETEST MEAN SCORES</th>
<th>GROUP 1</th>
<th>GROUP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Control</td>
</tr>
<tr>
<td>N</td>
<td>69</td>
<td>82</td>
</tr>
<tr>
<td>SAI (OTIS LENNON)</td>
<td>115.78</td>
<td>116.01</td>
</tr>
<tr>
<td>READING COMPREHENSION</td>
<td>80.39</td>
<td>78.60</td>
</tr>
<tr>
<td>MATH APPLICATIONS</td>
<td>79.00</td>
<td>81.26</td>
</tr>
<tr>
<td>MATH CONCEPTS</td>
<td>77.26</td>
<td>84.02</td>
</tr>
<tr>
<td>PRETEST</td>
<td>2.79</td>
<td>3.14</td>
</tr>
</tbody>
</table>
Instruments

The pretest/posttest consisted of seven items selected from the Public Release Item Bank for Grade Three from the 1986 National Assessment, published by the office of the National Assessment of Educational Progress in Washington, D.C. (See Appendix A). Items from the NAEP item bank were selected for the MCIP pretest/posttest on the basis of their ability to express student achievement as a result of direct learning from the MCIP card games or as a result of transfer of learning from playing the MCIP card-games. Each item was assessed nationally at the third grade level. Table 2 displays data regarding performance on the pretest. The p value was calculated after analyzing the sample population (n= 160) scores for each pretest item.

TABLE 2

<table>
<thead>
<tr>
<th>NAEP ITEM#</th>
<th>P VALUE</th>
<th>MCIP ITEM#</th>
<th>P VALUE</th>
<th>PURPOSE FOR NAEP CHOICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>72.4</td>
<td>1</td>
<td>85.63</td>
<td>Direct-Combinations of 10</td>
</tr>
<tr>
<td>12</td>
<td>73.0</td>
<td>2</td>
<td>49.38</td>
<td>Transfer-Multiplication</td>
</tr>
<tr>
<td>16</td>
<td>50.0</td>
<td>3</td>
<td>62.50</td>
<td>Transfer</td>
</tr>
<tr>
<td>17</td>
<td>42.0</td>
<td>4</td>
<td>26.88</td>
<td>Direct-Fraction Closest to 1</td>
</tr>
<tr>
<td>19</td>
<td>37.2</td>
<td>7</td>
<td>46.88</td>
<td>General Direct-How cards work with intuitively knowing the chances of increased or decreased.</td>
</tr>
<tr>
<td>21</td>
<td>21.4</td>
<td>6</td>
<td>23.75</td>
<td>Direct-Closest to 0</td>
</tr>
<tr>
<td>24</td>
<td>3.6</td>
<td>5</td>
<td>6.87</td>
<td>Direct-Statistics</td>
</tr>
</tbody>
</table>
National percentages are expressed as p values and also indicated for the items which appeared on the MCIP pretest/posttest (see Table 2).

After examining the p values for both the national assessment and pretest scores of students comprising the sample, the investigator noted that third graders do not usually begin work with multiplication facts or fractions until the second semester. The pretest was administered during the third week of school. The early test date may explain the low p value score for pretest item numbers two and four. NAEP calculated p values by combining scores from two testing periods during 1986. Administration of the NAEP first session instrument took place from January 6 to January 31, 1986. The second testing session took place from February 17 to May 2, 1986. Students in the 1986 NAEP assessment had an advantage of four to eight months of schooling over the sample population in this study.

The summary of student achievement for each item on the posttest was analyzed after collecting data. Chapter IV of this document contains the summary.

The 1986 NAEP Assessment enabled the investigator to compare the sample populations pretest and posttest scores with those of other students their age across the nation. In addition, use of this national item bank for the pretest/posttest added to the validity and reliability of the instrument. To insure internal validity, the investigator administered all pretests and posttests within the same week. All tests took place during the students' regular math class period. The pretests were administered during the week of September 17, 1990. Posttests were administered the week of November 12.
Teachers volunteered for participating in the study and chose whether they wished to be included in the treatment or control group. Teachers comprising the control group had taught for eleven to nineteen years. They had an average of 14 years of experience. Those in the treatment group had taught from zero to seven years, with an average of 3.75 years. One first year teacher was included in this group.

Teacher attitudinal changes toward mathematics were determined by using a portion of a survey employed in a study by Zito (1990). The survey included information about when teachers thought particular math topics should be introduced in the K-12 curriculum; how important teachers felt it was to teach integers, statistics, fractions, and math games; how easy it was to teach these four math topics; and how much teachers liked teaching these topics. The surveys were administered to the teachers in the control and treatment groups on the same day their students took the pretests and posttests. (See Appendix B for further information).

**Treatment**

The treatment implemented for this study followed the guidelines of effective staff development for teachers, as indicated by the research discussed in Chapter II. "Education is the only complex occupation where institutions have been ambivalent about providing continuing education for their employees" (Joyce and Showers, 1988, p. 2). Changing the practices of mathematics teaching depends on teachers, but "teachers cannot effect such reform without substantial systematic support and change" (NCTM, 1989b, p. 3).
It was expected that, if effective staff development research were put into practice, teachers participating in this study would have an efficient and economical means of implementing the Standards into their classrooms. As a result, the outcome of student achievement in mathematics would increase.

As mentioned in Chapter I, the pilot study conducted by the investigator in the spring of 1990 explored the use of two of the card games included in this study. Though teachers believed the games motivated students to learn mathematical concepts and, at the same time, enjoy math, the results of the study were not definitive. The results affirmed that further studies needed to be conducted in order to determine the cognitive effects of implementing “It’s in the Cards” games in math classes.

Teachers in the treatment group attended workshop sessions, videotaped a math lesson of their own to share with peers, shared ideas, and discussed concerns regarding the implementation of the card games. This kind of staff development program helped the teachers effectively implement the games in their classrooms.

Workshop sessions were approximately one hour in duration. At the first workshop, the group reviewed the purpose and goals for the project, as well as teacher expectations. Participants viewed a videotaped lesson of the investigator’s math class playing one of the card games. Discussion followed. The purpose of the video for this first session was to make teachers feel at ease with the investigator, as well as provide an example for taping their own math lessons. After introducing two card games, the investigator provided the teachers with a ten-minute period to plan how they were going to implement the
games the following day. Peer coaching was an important component of the treatment. Each teacher edited a ten-minute segment of a thirty-minute math lesson she had taped, then shared the tape with the group.

At the beginning of sessions two through four, teachers devoted ten minutes to discussion of implementing the games. In these sessions, teachers and students were encouraged to invent new versions of each game, to meet individual class needs. For instance, if students in one class already knew addition sums up to ten (skills reinforced in the game "Combinations of Ten"), they could play a new version of the game which might include combinations of 12, 13, 20, etc.

In addition, during this feedback time, teachers had the opportunity to share ideas about creative ways to introduce and incorporate the games into their math curriculum, as well as discuss any problems they were having.

After the ten-minute sharing session, teachers took ten minutes to view a segment of a participant's taped math lesson. A ten-minute discussion period followed. Teachers were encouraged to provide positive reinforcement, as well as suggestions for improvement.

With three sessions remaining after the first meeting, two teachers shared their taped lessons at the fourth session. Therefore, this session ran about twenty minutes over the planned hour. Each of the other two teachers shared their taped lesson during the second and third session.

The introduction of two new card games during each workshop session took fifteen minutes. As Stallings (1989) indicated in her study, teachers are most likely to implement new strategies if they are provided time to write down
how they will implement these strategies in their classrooms. Before leaving each session, participants shared their ideas for implementation with the investigator.

The games that were chosen for the first workshop session were “Peace” and “Combinations of Ten.” (See Appendix C for rules of all of the MCIP games). Both games reinforced the concept of whole numbers, which students are learning at the beginning of third grade. During all of the games, students worked in groups of two to four. Face cards were removed from the decks and aces equaled one. Each game had five rounds. One point was awarded to the winner of each round. The child who scored the most points at the end of five rounds won the game.

In session two, the games “Sum 29” and “Go For Zero” were introduced. “Sum 29” reinforced the whole number concept, but was more difficult to play than the two games previously introduced. “Go For Zero” introduced the concept of negative integers to third graders long before their textbooks would allow them the opportunity. Red cards were equal to negative integers and black cards equalled positive integers. Students chose two of the three cards they were dealt to make a combination that was closest or equal to zero.

Statistical games were introduced in the third session. Students learned to play “Mode,” “Median,” and “Mean.” (See Appendix C). Students were introduced to these concepts long before the present math curriculum would allow.

Games for the last session were “Fraction Closest to One” and “Largest Product.” (See Appendix C). If teachers followed the textbook for their grade
level, third graders would have had little exposure to fractions. It was expected that this game would help to introduce and reinforce the concept of fractions that relate to one whole.

Third graders are rarely provided the opportunity to learn how to do two- and three-digit multiplication problems. By employing calculators to compute their answers and by learning about probability or chance, (where to place the digits as they are called out), it was expected that students would develop strategies for placing digits so they could arrive at the largest product.

**Treatment Verification**

In order to give teachers at least one week to introduce and employ the new games with their students and to insure that the games were being implemented correctly, the investigator coached each teacher for a thirty-minute session the week following each workshop. In addition, teachers kept a daily log to indicate the amount of time the card games were played during their math periods.

The investigator kept a weekly log of time spent playing mathematical games, other than the MCiP card games, in both treatment and control math classes. All teachers were visited every Friday morning and asked the names of the games, the directions for playing the games, the percentages of students engaged in playing, and the total number of minutes each week devoted to mathematical game playing. Computer games were not considered as mathematical games for this study. The investigator considered only games
involving manipulatives and/or games involving student interaction with each other in small or whole-group activities.

In addition to having classroom visits by the investigator and keeping track of game time with daily and weekly logs, teachers videotaped one of the math lessons which introduced or implemented one of the card games.

Collection of Data

Data regarding the results of the pretests and posttests were collected, scored, and recorded by the investigator. In addition, data from the attitudinal surveys administered to teachers before and after treatment were compiled. Teachers in the treatment group kept a daily log regarding time spent implementing the MCIP card games in their classrooms. The investigator recorded data from observations in each coaching session (classroom observations) with participants in the treatment group. The investigator met weekly with all teachers in both control and treatment groups in order to collect data regarding the amount of time spent in math classes employing games other than the MCIP card games. Descriptions of the games, percentages of students playing, and time spent during each week playing games other than the MCIP card games were recorded.

In addition to four visitations to each treatment teacher's classroom, one videotaped lesson was collected from each teacher and analyzed by the investigator in order to help determine teacher creativity. If teachers had implemented the card games exactly as presented, they were coded as "not creative." Teachers who made minor changes to the suggested lessons were
coded as "mildly creative." Those who made major changes to lessons were coded as "creative." Teachers who made drastic changes or completely changed suggested lessons were coded as "highly creative." Detailed notes, which included comments and ideas made by teachers regarding creative implementation of the games were taken at each workshop session. From the notes and observations, tally marks were recorded for each teacher using the coding described above.

At the conclusion of the study, an independent investigator was hired to interview classroom teachers in the treatment group, as well as their students, regarding the impact (both anticipated and unanticipated results) of the treatment. Twenty-two percent of all students comprising the treatment group were interviewed.

**Research Design**

A quasi-experimental design was employed at the third grade level with intact classes. In order to insure triangulation, both quantitative and qualitative analyses were conducted. For the quantitative portion of the analysis, students were administered pretests and posttests to determine achievement in mathematics. Independent variables included group membership (treatment or control), and Stanford Achievement Test scores, which included the group Otis Lennon Test (SAI), Reading Comprehension, and Math Application portions of this instrument. Control variables were student performance for the pretest and Math Concepts portion of the achievement tests. The dependent variable was posttest achievement.
Statistical tests were run to determine the effects of the treatment on individual student achievement and problem solving ability. To establish the equivalence of the control and treatment groups, ANOVA was performed on achievement test scores. There were no significant differences between either of the groups in regard to student scores for SAI, Reading Comprehension, or Math Application. For Math Concepts, the control group had significantly higher scores at the .02 level. As a result, scores were adjusted. A repeated measures MANOVA was run on total pretest scores to determine whether the control and treatment groups varied significantly. The control group outperformed the treatment group on the pretest at a significant level of $p = .002$. As a result, both Math Concepts and Pretest were covaried to establish group equivalence in running further analyses. An analysis of covariance was performed on group posttest scores. The treatment group scored significantly higher than the control group at the .05 level. In order to determine which items on the posttest accounted for the variance, an analysis of covariance was performed on each of the posttest items, again using Pretest and Math Concepts as covariates. The experimental group outperformed the control group at a significant level on two of the posttest items ($p < .05$).

The effect the card games had on student achievement in mathematics, motivation, and enjoyment of mathematics was measured qualitatively through interviews with teachers and students in the treatment group. An independent investigator interviewed 22 percent of students in the treatment group. (See Appendix B for both Student and Teacher Surveys). The questions in the
student survey which guided the interview pertained to student opinion of the 
most and least favorite card games, descriptions of new games the teachers or 
students invented from the card games introduced, information regarding their 
teaching of the games to others outside of class, and opinions concerning the 
benefits of learning the card games. In addition, students were asked if they 
disliked anything about playing or learning the card games.

All four teachers in the treatment group were interviewed by the 
inependent investigator to determine the effects of the card games. Teachers 
were asked to determine the benefits of using the card games in their classes, 
relate any problems they encountered while implementing the games, share 
information regarding the games most and least liked by students, and provide 
information about feedback on using the games at home. Teachers were also 
asked to summarize the benefits of the workshop sessions and videotaping of 
personal lessons, as well as viewing those of peers. In addition, teachers were 
asked for recommendations for programming improvement and grade levels that 
could be included.

It was anticipated that introducing the MCIP card games would provide 
educators with an economical and efficient means of helping students learn and 
appreciate mathematics. As we urgently need to change the way math is being 
taught in our country, it was expected that the study would provide significant 
information concerning the power of play in regard to student mathematical 
problem solving ability, achievement, motivation, and enjoyment of mathematics.
CHAPTER IV

RESULTS

Introduction

The purpose of this study was to explore the power of play as a means for improving student achievement in mathematics. These card games provide the type of instruction endorsed by the Standards described in Chapter I. The card games became part of the mathematics classroom instruction for students participating in the study. In addition to improving student achievement, the card games were used as a means to accelerate the third grade curriculum, facilitating the introduction and understanding of mathematical concepts before they would normally be introduced at the third grade level.

An additional component of this research was an analysis of the effects of the inservice provided for participating teachers. Three analyses were performed in order to determine treatment effects. Teachers were administered an attitudinal survey before and after treatment. In addition, teacher creativity was measured during classroom observations, participation during workshops, and videotaped lessons. A third analysis tested whether teachers made a difference in regard to student achievement. This was accomplished by nesting
a class effect within each of the two groups (control and treatment) in the analysis of covariance. The results are reported in the ANOVA tables.

The Effect "It's in the Cards" had on Student Achievement

Student achievement was measured by seven items that comprised the pretest/posttest described in Chapter III. (See Appendix A). The test instrument consisted of seven items chosen for their ability to test mathematical concepts that were taught as a direct result from playing the MCIP card games, or as a transfer of learning from the games. All items were selected from the Public Release Item Bank for Grade Three from the 1986 National Assessment.

A number of analyses were performed in order to evaluate the results. The SAS and SPXX programs and the mainframe computer at Loyola University of Chicago were used to analyze the data. An analysis of variance, ANOVA, (SPSS-X, 1988) using group membership (treatment or control) as the independent variable, was performed on four subtests of the 1990 Stanford Achievement Tests, Form E, in order to establish equivalence between the control and treatment groups. The four subtests were SAI (School Acquired Information), which is a group Otis-Lennon test, Reading Comprehension, Math Applications and Math Concepts. There were no significant differences between groups on SAI, Reading Comprehension, or Math Applications. The control group scored significantly higher (F of 5.99, p = .02) on the Math Concepts portion of the achievement tests. Therefore, in subsequent analyses, Math Concepts was used as a covariate. To determine whether significant differences existed between groups on pretest performance, a repeated measures MANOVA
was run on pretest scores, again using group membership as the independent variable. The control group scored significantly higher on the pretest (F of 3.48, \( p = .002 \)). Due to the voluntary nature of the population, as often occurs in naturalistic settings, differences occurred between groups and were adjusted in further analyses using an analysis of covariance. Because intact classes were used and teachers volunteered for treatment or control conditions, in addition to the group effect, analyses were run for a class effect nested within each group to determine whether there were differences between classrooms.

Differences between the treatment and control groups were accounted for in the analysis of covariance performed on total posttest scores using Pretest and Math Concepts as the covariates. Posttest scores were adjusted in order to determine treatment effects on total math achievement. There was a significant effect between the control and treatment groups. The treatment group scored significantly higher on the posttest (F of 3.94 \( p = .05 \)). In order to determine which posttest items accounted for the variance, an analysis of covariance was performed on each posttest item, again controlling for Pretest and Math Concept scores.

**Analysis of Variance**

Equivalence was established between the control and treatment groups by performing an ANOVA on scores reported for the 1990 Stanford Achievement Tests, which was administered in March of 1990. The unadjusted group means and standard deviations for SAI (group Otis-Lennon), Math Concepts, Math Application and Reading Comprehension are listed in Table 3. One class was dropped from the sample, as discussed in Chapter III, for the reason that
students in this class scored well below others in the study. Of the 160 remaining in the sample, who were administered both the pretests and posttests, nine did not have achievement test scores, resulting in 151 with scores.

TABLE 3

UNADJUSTED 1990 ACHIEVEMENT TEST SCORE MEANS

<table>
<thead>
<tr>
<th></th>
<th>GROUP 1</th>
<th>GROUP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Control</td>
</tr>
<tr>
<td>N = 151</td>
<td>69</td>
<td>82</td>
</tr>
<tr>
<td>SAI (OTIS-LENNON)</td>
<td>115.78</td>
<td>12.675</td>
</tr>
<tr>
<td>READING COMPREHENSION</td>
<td>80.39</td>
<td>18.863</td>
</tr>
<tr>
<td>MATH APPLICATIONS</td>
<td>79.00</td>
<td>21.059</td>
</tr>
<tr>
<td>MATH CONCEPTS</td>
<td>77.26</td>
<td>18.617</td>
</tr>
</tbody>
</table>

Group equivalence was measured by determining whether significant differences existed between the control and treatment groups on four measures of the 1990 Stanford Achievement Tests. The ANOVA results are displayed in Table 4.
There was a significant effect between the control and treatment groups for performance on Math Concepts ($p = .02$). Scores were adjusted for further analyses that were performed.

Pretest/Posttest Reliability

The intraclass correlation coefficient, which indicates the reliability for the pretest and posttest, was .15 and .14 respectively. As a result of these low reliabilities, a repeated measures MANOVA was run on pretest items to determine whether significant differences existed between groups.

Repeated Measures Multiple Analysis of Variance

A repeated measures MANOVA was performed on pretest scores for both control and treatment groups in order to determine whether significant differences existed between groups. Pretest scores and standard deviations for each class are listed in Table 5.
The Cochrans homogeneity of variance test (SPSS-X, 1988) performed on pretest scores revealed that there were no significant differences between groups.

Inferential data for the MANOVA performed on total pretest scores for both the control and treatment groups are disclosed on Table 6.
There was a significant effect between pretest scores and group \((p = .002)\). An examination of group means revealed the control group outperformed the treatment group. Therefore, in order to establish group equivalence to examine the effects, posttest scores were adjusted for subsequent analysis using Pretest and Math Concepts as the covariates.

**Analysis of Covariance**

Using Pretest and Math Concepts as covariates, an analysis of covariance was performed on the total score of all seven items on the posttest for both the control and treatment groups. Table 7 reports the unadjusted and adjusted descriptive data.
### TABLE 7

<table>
<thead>
<tr>
<th></th>
<th>Class</th>
<th>Observed Means</th>
<th>S.D.</th>
<th>Adj. Means</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.28</td>
<td>1.18</td>
<td>3.05</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.91</td>
<td>1.87</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.82</td>
<td>.96</td>
<td>3.98</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.81</td>
<td>1.08</td>
<td>3.31</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.46</strong></td>
<td><strong>3.33</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.33</td>
<td>1.50</td>
<td>3.75</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5.22</td>
<td>1.17</td>
<td>4.60</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.25</td>
<td>1.13</td>
<td>4.13</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2.53</td>
<td>1.66</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.83</strong></td>
<td><strong>3.95</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Performing Cochrans homogeneity of variance test (SPSS-X, 1988) on the posttest scores revealed that a significant difference existed between the control and treatment groups ($p = .048$).

Because the sample consisted of intact classes and teachers volunteered for treatment or control conditions, in addition to the group effect, analyses were
run for a class effect nested within each group in order to determine whether
differences occurred between classroom teachers. Table 8 reports the ANOVA
for total posttest scores, controlling for Math Concepts and Pretest.

TABLE 8

<table>
<thead>
<tr>
<th>ANOVA FOR TOTAL POSTTEST SCORES</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WITH COVARIATES MATH CONCEPTS AND-PRETEST</td>
<td>DF</td>
<td>SS</td>
<td>MS</td>
<td>F</td>
<td>Sign F</td>
</tr>
<tr>
<td>Regression</td>
<td>2</td>
<td>50.24</td>
<td>25.12</td>
<td>16.86</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>5.86</td>
<td>5.86</td>
<td>3.94</td>
<td>.049 *</td>
</tr>
<tr>
<td>ClassW (Treatmt)</td>
<td>3</td>
<td>10.87</td>
<td>3.62</td>
<td>2.43</td>
<td>.068</td>
</tr>
<tr>
<td>ClassW (Control)</td>
<td>3</td>
<td>9.76</td>
<td>3.25</td>
<td>2.18</td>
<td>.093</td>
</tr>
<tr>
<td>Within Cells</td>
<td>141</td>
<td>210.04</td>
<td>1.49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. * p < .05

An examination of group means indicated that the treatment group
significantly outperformed the control group on total adjusted posttest scores (p = .05). An examination of the effect of the covariates, or regression effect,
indicated that student performance on the pretest and Math Concepts portion of
the achievement tests together significantly affected performance on the posttest
at the p < .05 level. Correlations between the pretest, Math Concepts, and
posttest scores in Table 9 revealed that the pretest standardized regression
coefficient was pretest performance .36, while Math Concepts scores was .19.
Data on Table 9 revealed there was a high correlation between student performance on the Pretest and Math Concepts portion of the achievement tests \( (p < .05) \), in relation to how well students performed on the posttest.

The strength of association test, Omega squared, was calculated for each of the contributing variables to determine their effect on the posttest scores. Omega squared for the covariates pretest and Math Concepts was .17, indicating 17 percent of the variance was accounted for by these variables. Group (control or treatment) accounted for two percent of the variance. Classes within the experimental and control groups each accounted for two percent of the variance. Failure to pass the Cochrans homogeneity of variance test (SPSS-X, 1988) applied to total posttest scores \( (p = .048) \), limited the generalizability of these results and further examinations were needed. To determine which posttest items were accounting for the significant difference between the control and treatment groups, the posttest items were analyzed individually.
An analysis of covariance, controlling for Pretest and Math Concepts scores, was performed for individual posttest items. (See Appendix A for Posttest). Information regarding student performance for Posttest Item One is displayed in Table 10. Item One asks students to find the total number of marbles in fifteen bags, if each bag holds ten marbles. Students are asked to multiply or count by ten. Information that follows includes the ANOVA for this item, and correlations of student performance with the Pretest and Math Concepts.
### TABLE 10

**DESCRIPTIVE DATA**

**POSTTEST ITEM 1**

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Means</th>
<th>S.D.</th>
<th>Adj. Means</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONTROL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>.78</td>
<td>.428</td>
<td>.85</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>.86</td>
<td>.359</td>
<td>.85</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>.96</td>
<td>.213</td>
<td>.88</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
<td>.91</td>
<td>.301</td>
<td>.85</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>.86</strong></td>
</tr>
<tr>
<td><strong>TREATMENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>.83</td>
<td>.383</td>
<td>.89</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>.83</td>
<td>.383</td>
<td>.80</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>1.00</td>
<td>.000</td>
<td>.96</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>.71</td>
<td>.470</td>
<td>.78</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>.86</strong></td>
</tr>
</tbody>
</table>

Performing a Cochrans homogeneity of variance test *(SPSS-X, 1988)* on student performance for Posttest Item One revealed that there was no significant difference between groups (*p* = .080). Table 11 displays data for the ANOVA performed on Posttest Item One.
It can be determined from the ANOVA table that the control and treatment groups did not differ significantly on Posttest Item One. When examining the Pretest Item One scores and Math Concepts scores with Posttest Item One scores in Table 12, student performance on Pretest Item One did not have an effect on their posttest score. However, performance on Math Concepts significantly affected student performance on posttest Item One (p < .05), though its standardized regression coefficient was only .17.
TABLE 12

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Correl.</th>
<th>B</th>
<th>Beta</th>
<th>Std. Err.</th>
<th>T-Value</th>
<th>Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>.33956</td>
<td>.0291053274</td>
<td>.0298572271</td>
<td>.08212</td>
<td>.35442</td>
<td>.724</td>
</tr>
<tr>
<td>MConc</td>
<td>.98621</td>
<td>.0043121067</td>
<td>.1697004204</td>
<td>.00214</td>
<td>2.01444</td>
<td>.046 *</td>
</tr>
</tbody>
</table>

Note. * p < .05

Information regarding Posttest Item Two can be found on Table 13. Item Two tests multiplication facts and asks students to complete the number sentence $3 \times ____ = 21$. An analysis of covariance was performed on this posttest item, using Pretest and Math Concepts as the covariates. Information that follows includes the ANOVA for this item, correlations with the Pretest and Math Concepts, and a post-hoc analysis.
The Cochrans homogeneity of variance test (SPSS-X, 1988) performed on Posttest Item Two, revealed that there were no significant differences between groups (p = .703). Data regarding the ANOVA for posttest Item Two are included in Table 14.
**TABLE 14**

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sign F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>2.27</td>
<td>1.13</td>
<td>.671</td>
<td>.002 *</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.53</td>
<td>.53</td>
<td>3.14</td>
<td>.076</td>
</tr>
<tr>
<td>ClassW (Treatm)</td>
<td>3</td>
<td>1.35</td>
<td>.45</td>
<td>2.67</td>
<td>.050 *</td>
</tr>
<tr>
<td>ClassW (Contrl)</td>
<td>3</td>
<td>1.94</td>
<td>.65</td>
<td>3.83</td>
<td>.011 *</td>
</tr>
<tr>
<td>Within Cells</td>
<td>141</td>
<td>23.81</td>
<td>.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. * p < .05

There were no significant differences between the control and treatment groups regarding student performance for this item. However, classes within both groups varied significantly in performance. Classes within the treatment group varied at the significant level of p = .050 while classes within the control group differed at the p = .011 level. It can be concluded from the regression score that together, performance on Pretest Item Two and Math Concepts had a significant effect on student performance on Posttest Item Two, at the .002 level. A further investigation of this effect is displayed on Table 15.
It was concluded that performance on Pretest Item Two ($p = .006$) and Math Concepts ($p = .043$) had significant effects on student performance for Posttest Item Two with a standardized regression coefficient of .23 and .17 respectively. To further explore differences in classes within the treatment group, Tukey's Honestly Significant Difference post-hoc analysis was performed. The results are displayed in Table 16. To account for the variance between classes, it was determined that class seven outperformed classes six and nine in the treatment group at a significant level ($p < .05$) on Posttest Item Two.
The strength of association test, Omega squared, was calculated for each of the contributing variables to determine their effect on the Posttest Item Two scores. Omega squared for the covariates pretest and Math Concepts was .07, accounting for 17 percent of the variance. Group membership accounted for one percent of the variance; classes within the treatment group accounted for three percent, and classes within the control group accounted for five percent.

Data regarding Posttest Item Three are found in Table 17. Item Three asks students to choose the correct number sentence for a problem asking "If Sam has 68 baseball cards. Juanita has 127 . . . how many more cards does Juanita have than Sam?" An analysis of covariance was performed on this
posttest item, using Math Concepts and Pretest as the covariates. Information that follows includes the ANOVA for this item, correlations with the pretest and Math Concepts, and a post hoc analysis.

### TABLE 17

**DESCRIPTIVE DATA**

**POSTTEST ITEM 3**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>N</th>
<th>MEANS</th>
<th>S.D.</th>
<th>ADJ. MEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>.56</td>
<td>.511</td>
<td>.65</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>.57</td>
<td>.507</td>
<td>.58</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>.96</td>
<td>.213</td>
<td>.85</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
<td>.95</td>
<td>.218</td>
<td>.88</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>.74</td>
</tr>
<tr>
<td>TREATMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>.50</td>
<td>.514</td>
<td>.58</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>.94</td>
<td>.236</td>
<td>.89</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>.87</td>
<td>.342</td>
<td>.82</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>.41</td>
<td>.507</td>
<td>.52</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>.70</td>
</tr>
</tbody>
</table>
The Cochrans homogeneity of variance test (SPSS-X, 1988) performed on Posttest Item Three, revealed that there were no significant differences between groups (p = .277). Information regarding the analysis of covariance for this item, controlling for Pretest and Math Concepts, follows in Table 18.

TABLE 18

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>E</th>
<th>Sign F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>.87</td>
<td>.43</td>
<td>2.78</td>
<td>.065</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.04</td>
<td>.04</td>
<td>.24</td>
<td>.627</td>
</tr>
<tr>
<td>ClassW (Treatm)</td>
<td>3</td>
<td>1.22</td>
<td>.41</td>
<td>2.61</td>
<td>.050 *</td>
</tr>
<tr>
<td>ClassW (Cont)</td>
<td>3</td>
<td>1.08</td>
<td>.36</td>
<td>2.30</td>
<td>.080</td>
</tr>
<tr>
<td>Within Cells</td>
<td>141</td>
<td>21.94</td>
<td>141</td>
<td>.16</td>
<td></td>
</tr>
</tbody>
</table>

Note. * p = .05

It can be concluded from the ANOVA Table that there were no significant differences between the control and treatment groups on this posttest item. Table 19 reports correlations between performance on Pretest Item Three, Math Concepts, and Posttest Item Three. There were significant differences between classes within the treatment group at the p = .050 level.
The results on Table 19 indicate that performance on Math Concepts had a direct effect on performance on Posttest Item Three at the $p = .027$ level, though its standardized regression coefficient was only $.18$. There were no significant differences between performance on Pretest Item Three and this posttest item.

Table 18 displayed data that indicated significant differences among classes within the treatment group ($p = .05$). Tukey's Honestly Significant Difference post-hoc analysis was performed to determine which of the classes accounted for the differences. The results are indicated in Table 20.
Student performance followed the same pattern for Posttest Item Three, as it did for Posttest Item Two. Classroom seven again outperformed both classes six and nine.

The strength of association test, Omega squared, was calculated for each of the contributing variables to determine their effect on Posttest Item Three scores. Omega squared for the covariates Pretest and Math Concepts was .03, indicating three percent of the variance. Group membership accounted for negligible variance. Classes within the treatment group accounted for three percent of the variance; classes within the control group two percent.
Data regarding descriptive information for posttest Item Four are reported on Table 21. Item Four asks students to write a fraction using numerals for three-fourths. An analysis of covariance was performed on this item, using Pretest and Math Concepts as the covariates. Information on following tables includes the ANOVA results, and correlations between performance on posttest, pretest, and Math Concepts.

<table>
<thead>
<tr>
<th>TABLE 21</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTIVE DATA</strong></td>
</tr>
<tr>
<td><strong>POSTTEST ITEM 4</strong></td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
</tr>
<tr>
<td>Class</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>TREATMENT</strong></td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Cochrans homogeneity of variance test (*SPSS-X, 1988*) performed on posttest Item Four revealed that there were no significant differences between groups (p = .845). An analysis of covariance was performed on Posttest Item Four, controlling for Pretest and Math Concepts. The results are reported in Table 22.

**TABLE 22**

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sign F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>3.76</td>
<td>1.84</td>
<td>11.35</td>
<td>.000 *</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>6.16</td>
<td>.014 *</td>
</tr>
<tr>
<td>ClassW (Treatm)</td>
<td>3</td>
<td>.84</td>
<td>.28</td>
<td>1.73</td>
<td>.164</td>
</tr>
<tr>
<td>ClassW (Contri)</td>
<td>3</td>
<td>.41</td>
<td>.14</td>
<td>.85</td>
<td>.469</td>
</tr>
<tr>
<td>Within Cells</td>
<td>141</td>
<td>22.81</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. * p < .05

It can be concluded from the ANOVA Table that there was a significant difference between groups for this posttest item. An examination of means (p = .014) revealed that the treatment group outperformed the control group at a significant level. There were no significant differences in performance for this item between classes within either the control or treatment groups. Combined performance on Pretest Item Four and Math Concepts had a direct effect on performance for Posttest Item four. Table 23 reports data that further
investigates this relationship; correlations for performance on Pretest Item Four, Math Concepts, and Posttest Item Four.

TABLE 23

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Correl.</th>
<th>B</th>
<th>Beta</th>
<th>Std. Err.</th>
<th>T-Value</th>
<th>Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest 4</td>
<td>.80441</td>
<td>.3566851283</td>
<td>.3096952686</td>
<td>.09099</td>
<td>3.92007</td>
<td>.000 *</td>
</tr>
<tr>
<td>MConc</td>
<td>.56811</td>
<td>.0052819221</td>
<td>.1664297224</td>
<td>.00251</td>
<td>2.10664</td>
<td>.037 *</td>
</tr>
</tbody>
</table>

Note. * p < .05

The results in Table 23 revealed that performance for Pretest Item Four had a direct relationship to posttest Item Four performance at the p < .05 level with a standardized regression coefficient of .31. In addition, achievement on Math Concepts also had a direct effect on how well students performed on Posttest Item Four at the .037 level, though its standardized regression coefficient was only .17.

The strength of association test, Omega squared, was calculated for each of the contributing variables to determine their effect on Posttest Item Four scores. Omega squared for the covariates pretest and posttest was .12 indicating 12 percent of the variance. Group membership accounted for three percent of the variance, while classes within the treatment group accounted for one percent. Classes within the control group accounted for a negligible amount of variance.
Data regarding Posttest Item Five are displayed in Table 24. This item of the posttest was the most difficult for students to solve correctly. It asks students to find the average age of five children, whose ages are thirteen, eight, six, four, and four respectively. The analysis of covariance performed controlled for Pretest and Math Concepts. Information in the tables that follow includes ANOVA for this posttest item, and correlations with performance on the Pretest, and Math Concepts.

**TABLE 24**

<table>
<thead>
<tr>
<th>POSTTEST ITEM 5</th>
<th>\</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>\</th>
<th>\</th>
<th>\</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>N</td>
<td>Means</td>
<td>S.D.</td>
<td>Adj. Means</td>
</tr>
<tr>
<td>-------</td>
<td>---</td>
<td>-------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>.06</td>
<td>.236</td>
<td>.05</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>.05</td>
<td>.218</td>
<td>.04</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>.18</td>
<td>.395</td>
<td>.20</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
<td>.05</td>
<td>.218</td>
<td>.05</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>.09</td>
<td>\</td>
<td>\</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>\</th>
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<th>\</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>18</td>
<td>.00</td>
<td>.000</td>
<td>-.01</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>.06</td>
<td>.236</td>
<td>.06</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>.00</td>
<td>.000</td>
<td>.02</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>.00</td>
<td>.000</td>
<td>-.01</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>.02</td>
<td>\</td>
<td>\</td>
</tr>
</tbody>
</table>
The Cochrans homogeneity of variance test (SPSS-X, 1988) revealed that groups differed significantly at the $p = .020$ level. However, performance was so low in both groups, that perhaps students correctly solved this item by chance only. In this event, it would appear this test item is invalid.

### TABLE 25

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sign F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>.19</td>
<td>.09</td>
<td>1.94</td>
<td>.148</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.01</td>
<td>.01</td>
<td>.16</td>
<td>.688</td>
</tr>
<tr>
<td>ClassW (Treatm)</td>
<td>3</td>
<td>.05</td>
<td>.02</td>
<td>.31</td>
<td>.818</td>
</tr>
<tr>
<td>ClassW (Contrl)</td>
<td>3</td>
<td>.32</td>
<td>.11</td>
<td>2.21</td>
<td>.090</td>
</tr>
<tr>
<td>Within Cells</td>
<td>141</td>
<td>6.88</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An investigation of the data on Table 25 revealed that, there were no significant differences between groups. There were no significant effects among the other variables, as well. Table 26 reports the correlations between performance on Pretest Item Five, Math Concepts and Posttest Item Five. The data indicated that, there was no correlation in performance on Pretest Item Five, Math Concepts, or Posttest Item Five.
Data regarding Posttest Item Six are recorded on Table 27. Item Six asks students to analyze the relationship of points on a given number line \( (a < b) \). An analysis of covariance was performed on this item, controlling for Pretest and Math Concepts. Information in the tables that follow includes the ANOVA for this posttest item, and correlations with performance on the Pretest and Math Concepts.
The Cochrans homogeneity of variance test (SPSS-X, 1988) revealed that there were no significant differences between groups (p = 1.000). Information regarding the ANOVA follows on Table 28.
It can be concluded from the ANOVA Table that there were no significant differences regarding performance for this item between the control and treatment groups. However, the regression score revealed that performance on Pretest Item Six and Math Concepts together had a significant effect on performance for posttest Item Six at the $p = .002$ level. To investigate this relationship further, performance on Pretest Item Six, Math Concepts, and Posttest Item Six were correlated. The data are presented on Table 29.
TABLE 29

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Correl.</th>
<th>B</th>
<th>Beta</th>
<th>Std. Err.</th>
<th>T-Value</th>
<th>Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest 6</td>
<td>.98855</td>
<td>.33303533353</td>
<td>.2821881145</td>
<td>.09540</td>
<td>.3.49136</td>
<td>.001 *</td>
</tr>
<tr>
<td>MConc</td>
<td>.21822</td>
<td>.0015685097</td>
<td>.0436306159</td>
<td>.00291</td>
<td>.53982</td>
<td>.590</td>
</tr>
</tbody>
</table>

Note. * p < .05

These results indicate that though there was little effect on performance as a result of Math Concepts and performance on Posttest Item Six, student performance on Pretest Item Six significantly affected their performance on Posttest Item Six at the .001 level and had a standardized regression coefficient of .28.

Data regarding Posttest Item Seven appears on Table 30. Item Seven presents students with illustrations of three different sized bags of marbles. One bag contains 10 marbles and the others contain one hundred and one thousand. Students are asked to determine which bag would give them the greatest chance of picking a red marble, if only one red marble existed in each of the three bags.

Pretest and Math Concepts were covaried in the analysis of covariance performed on this posttest item. Information on tables that follow includes the ANOVA and correlations between performance on posttest, pretest, and Math Concepts.
The Cochrans homogeneity of variance test (SPSS-X, 1988) revealed that there were no significant differences between groups for this item (p = 1.000). The data regarding the ANOVA is presented in Table 31.
It can be concluded that there was a significant difference between groups. An examination of adjusted means revealed that, the treatment group outperformed the control group at a significant level (p = .038). In addition, the regression score revealed that performance on Pretest Item Seven and Math Concepts together had a significant effect on performance for posttest Item Seven at the .000 level. To further investigate this relationship, data are displayed in Table 32 indicating the relationship between performance on Pretest Item Seven, Math Concepts, and Posttest Item Seven.
TABLE 32

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Correl.</th>
<th>B</th>
<th>Beta</th>
<th>Std. Err.</th>
<th>T-Value</th>
<th>Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>.98820</td>
<td>.401681</td>
<td>.39237284</td>
<td>.08020</td>
<td>5.00827</td>
<td>.000</td>
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<tr>
<td>MConc</td>
<td>.22221</td>
<td>.000822</td>
<td>.02414614</td>
<td>.00266</td>
<td>.30820</td>
<td>.758</td>
</tr>
</tbody>
</table>

Note. * p < .05

These results revealed that, though there was little difference between performance on Math Concepts and performance on Posttest Item Seven, student performance on Pretest Item Seven significantly affected their performance on Posttest Item Seven at a highly significant level (p = .000) with a standardized regression coefficient of .39.

The strength of association test, Omega squared, was calculated for each of the contributing variables to determine their effect on Posttest Item Seven scores. Omega squared for the covariates pretest and Math Concepts was .14 indicating 14 percent of the variance was accounted for by the covariates. Group membership accounted for two percent of the variance. Classes within the treatment group accounted for .7 percent and classes within the control group accounted for .5 percent of the variance.
Teacher Attitudinal Changes

Teachers in the both the control and treatment groups were administered an attitudinal survey developed by Zito (1990) before and after treatment. (See Appendix B). Teachers in the control group made little or no changes in their responses before or after treatment. Treatment teachers indicated a number of changed attitudes. Although Zito found significant changes in teacher attitude in her study, which was conducted over one year, findings from this investigation were not conclusive. The one first-year teacher in the treatment group was noncommittal and marked “undecided” for every item regarding whether particular math topics should be introduced into the curriculum at the third grade level. Overall, most of the teachers who responded that algebra, integers, statistics, and data collection should not be introduced at the third grade level, had changed their minds by the end of the treatment period.

Teachers were asked to rank the importance, ease of teaching and degree to which they liked teaching integers, statistics, fractions, and math games. Though all four teachers responded before treatment that they were “undecided” about how difficult it was to teach integers, only one responded the same after treatment, two believed teaching integers was “easy,” and one believed it was “hard.” In addition, they all responded that they liked teaching integers after treatment, whereas before treatment, only one indicated this, and the other three felt “undecided.”

After treatment, all had responded that teaching statistics was either “very important” or “important,” whereas before treatment, three responded in this manner, while one was “undecided.” While all believed that teaching statistics
was either "easy" (two) or they were "undecided" (two) before treatment, no one was undecided after treatment and two responded that it was "hard" to teach. Teachers were also split on whether they liked teaching statistics, for two responded that they liked teaching the topic, while the other two responded they were "undecided." After treatment, only one was "undecided," while three felt that they either "liked" teaching statistics, or they "liked it a lot."

Teachers did not change their beliefs about the importance of teaching fractions at the third grade level. All of them responded that it was either "very important" or "important." They also did not change feelings about the ease of teaching fractions. Two felt that fractions were "easy" to teach, while one was "undecided," and one believed it was "hard" to teach fractions. Their ratings of how much they liked teaching fractions changed. While two "liked" teaching fractions before treatment, the other two responded that they were either "undecided" or they "didn't like" teaching fractions. After treatment, all four teachers responded "liked" or "liked a lot" in rating their feelings about teaching fractions.

Finally, all four teachers believed that teaching math games was "very important" after treatment, while only two felt this way beforehand. While all four believed that teaching math games was easy before treatment, three responded in this manner on the post survey, and one responded that they were "very easy" to teach. While teachers believed they either "liked a lot" or "liked" teaching math games before treatment, all four indicated "liked a lot" on the post survey.
**Teacher Creativity**

In addition to the surveys, anecdotal data were collected regarding teacher creativity from classroom observations, videotapes, and workshop sessions. Teachers were coded as “not creative” if they had presented the card games exactly as they were introduced to them. “Mildly creative” teachers were those who made minor changes in their lessons. “Creative” teachers made major changes in the lessons, while “highly creative” teachers made dramatic changes in how they presented the card games to their students. Tally marks were recorded for each lesson observed, and for remarks made during workshop sessions regarding teacher implementation of the games and coded accordingly.

Three of the four treatment teachers had seven codes and one received eight. Almost all of the teachers had the same coding scores. All received at least two to three codes in both the “Mildly Creative” and “Highly Creative” categories. The majority of the codes fell into these two categories. The average number of years teaching for this group was 3.75 years. This could account for their willingness to try new ideas, materials and methods of teaching, and adapt them to their own class’s special needs. In addition, the card games are easy manipulative materials to employ in the classroom and lend themselves to creative use.

The treatment teacher in class seven had a student teacher who taught math for the majority of the treatment time. The regular classroom teacher was coded for only the first classroom observation. The regular classroom teacher, rather student teacher, attended workshop sessions and shared information about how the games were being implemented in her classroom. The student
teacher implemented the card games as instructed by the classroom teacher. In addition, it was the student teacher, rather than the classroom teacher, who submitted the videotaped lesson, which was observed during one of the workshop sessions.

**Motivation, Interest, and Enjoyment of Mathematics**

In addition to the data obtained from the test instrument, anecdotal data were gathered during and at the conclusion of this investigation. An independent investigator interviewed all four teachers and 17, or 22 percent, of the students comprising the treatment group. (See Appendix B for surveys used to guide the interviews). The purpose of the interviews was to gather information regarding the effects of the games on student achievement, motivation, interest and enjoyment of mathematics.

Teachers felt that the students loved and enjoyed playing the math games, though some students did not completely understand the concepts. They believed that the games helped students' problem-solving skills, and that the real-life game playing helped to make math fun, and "not at all textbook related." One teacher noted that the games "enhanced learning potential for my students." Another remarked that "the hands-on reinforcement of mathematical concepts was good. I taught some of the parents the games at conferences."

Though teachers believed the games were an effective way to teach math concepts and implement the Standards, they were confronted with a few problems. One felt her students were not ready for much of the material, and that introducing two new games every two weeks was too much. Another
agreed that the workshops were "too fast paced - there was no leisure time during this project." The first-year teacher complained that her class was "wild" and that it was hard for her to keep them on task. She also felt that not all of her students worked well in groups.

Though the teachers felt all of their students enjoyed all of the games, they believed "Largest Product" was the most well liked by students, due to the fact they could use hand calculators in order to compute their answers. One teacher felt that "Go for Zero" and "Fraction Closest to One" were too difficult for her class. Though her students found "Sum 29" to be difficult also, when the rules were changed to "Sum 15," the students had no problems.

When asked if parents had made any comments about the games, one teacher replied, "None from parents. However, the games did change my way of teaching math, and parents responded positively to that. They liked the 'hands-on' philosophy."

One teacher had mentioned that a number of parents commented positively about the games at conferences. One remarked, "My daughter is teaching the games to us at home. We love them!"

When teachers were asked about the benefits of the workshops, they felt the sharing sessions provided the opportunity to learn a variety of approaches to introducing the games and math concepts they taught, as well as a chance to discuss common problems. Though one teacher felt very uncomfortable about seeing herself on videotape, all felt that it provided them a chance to see their students' reactions when they taught. They all enjoyed watching each other teach, and sharing ideas and possible changes to the lessons they observed.
One remarked, "The staff development component had the right amount of involvement."

The common complaint from all of the treatment teachers was that they felt too much information was given too soon, and that they did not devote the proper amount of time needed to implementing the math games in their classrooms.

Seventeen students in the treatment group were interviewed at the end of the treatment period. Most of the students answered that they liked playing the games because they were fun to play and that they helped them learn math. Students preferred playing particular games for various reasons. One preferred "Sum 29" because he said he "felt like a businessman firing people when I won." Another liked "Median" because "I learned what median means."

"Go for Zero" was a favorite game for some. One student "liked trying to get zero," and another liked it because he enjoyed working with negative numbers.

When students were asked how the card games helped them to learn math, they had a variety of responses. One student remarked that remembering how to play the games helped him to do his math homework. Five students answered that playing the games made them "better" at math. Three answered that they were better able to understand problems, and three said that they were able to learn about numbers. One answered that the card games "helped me learn new skills." Another answered, "I'm faster at doing things in my head." Additional student responses were that they had increased their ability to learn
basic math facts and fractions, and were better able to do more difficult mathematical problems.

When asked if there was anything they didn’t like about playing the games 15 of the 17 students interviewed said that they liked playing them. One said that there were too many games to learn, and another said that he lost most of the time. A number of the students liked the games so much that they taught them to family members, babysitters, and friends.

Analysis of the Results

Student achievement in mathematics improved by implementing “It’s in the Cards” into math classes at the third grade level. Table 8 supports this conclusion in the analysis of covariance. It may be concluded from the analyses that the treatment group made significant overall gains in posttest scores over the control group at the .05 level. To further explore this effect, an analysis of covariance was performed for each posttest item, to determine which items were accounting for the variance. Table 22 supports the conclusion that the treatment group outperformed the control group on item four (p = .01). Table 31 presents supporting data that the treatment group outperformed the control group on Item Seven (p < .05).

The way that teachers implement the card games can also affect the way children learn. This idea is supported in Table 16 and Table 20 with data from the post hoc tests performed on items two and three. On these two items of the posttest, class seven outperformed both classes six and nine.
Anecdotal data collected revealed that the games investigated for this study promoted motivation, interest, and enjoyment of mathematics for participating students and teachers. The survey revealed that the card games changed teachers' attitudes about appropriate mathematics curriculum for the third grade. The general conclusion is that treatment teachers believe that more advanced topics can be included, and that they are easy and fun to teach. In addition, they had changed their minds about using games. At the end of the treatment period all of them believed that teaching math games was very important.

The card games are good instructional materials that capitalized on creativity. Teachers were able to creatively implement them into their math classes and adapt them to their own class's special needs.

The results from the interviews indicated that teachers, as well as students, believed that the games helped to enhance learning potential. Making students active participants in mathematics was exciting for teachers and students. The teachers believed the games allowed them to depart from routine use of the textbook and provided real-life activities that made teaching and learning math fun. In some instances, teachers responded that the games changed the way they taught mathematics.

Teachers and students believed that the games helped to teach problem solving in an enjoyable manner. Different children liked different games for various reasons. Students believed that it was fun to talk and learn while playing. In addition, they enjoyed learning the advanced concepts that were presented to them. The games provided a nontoxic means (for students
and teachers) for incorporating the calculator into the classroom, as well.

A number of students shared the games with family members, friends, and babysitters. In this manner, they provided an excellent link between home and school and promoted parent involvement.
CHAPTER V

DISCUSSION

Introduction

The purpose of this study was to investigate whether students would have increased achievement in mathematics as a result of integrating eight mathematical card games into third grade math classes. The card games provided an efficient, cost-effective means for implementing the mathematical standards outlined in the Curriculum and Evaluation Standards for School Mathematics (Standards), a document published by the National Council of Teachers of Mathematics (NCTM).

Research in school change supports the need for staff development. Implementation of the NCTM Standards will require intensive training for teachers if they are to change the way mathematics is currently being taught. A staff development model was designed to assist teachers in the implementation of the Standards through mathematical card games.

In September and October of 1990, four workshops were presented to teachers in the treatment group. The sessions focused on creative implementation of eight of the “It’s in the Cards,” mathematical card games developed by Dr. Diane Schiller and other members of the Mathematics
Curriculum Improvement Project (MCIP). A seven-item pretest, composed of released items from the National Assessment of Educational Progress (NAEP) was administered to five control and four treatment groups before implementation of the first card game. Participants were instructed to introduce to their students the nontraditional mathematical concepts which were taught by playing the card games. Teachers were asked to spend about ten minutes per day, or fifty minutes per week during math time, playing the games introduced at workshop sessions. In addition to implementation of the games, teachers videotaped a math lesson to share with other participating teachers at the workshop sessions. The investigator visited treatment classes the week following each workshop session to verify implementation of the games.

After the implementation period, the same seven-item test was used as a posttest. Analyses were performed in order to determine whether students in the treatment group made significant gains in math achievement over students in the control group.

**Findings and Conclusions**

One of the most important finding from this study is that games can be powerful tools for teaching mathematical concepts. Students in the treatment group not only achieved more overall than students in the control group, but also gained an understanding of how math can be a part of their everyday lives. Playing the card games encouraged communication of math, introduction of advanced concepts, and reinforcement of basic skills. Having students defend their answers promoted mathematical reasoning. In the statistical card games
patterns of numbers and relationships were stressed. Estimation, place value, numbers sense, and numeration were introduced in several of the games. Advanced mathematical concepts such as statistics, negative integers, and three-digit by two-digit multiplication became a part of the curriculum for participating students. Technology entered the math class when hand calculators were employed to play the game “Largest Product.” In addition, motivation, interest and enjoyment of mathematics were enhanced as a result of implementing the MCIP card games into third grade math classes.

Games were also a powerful device for teaching students social skills. Taking turns for dealing and drawing cards, and keeping score, as well as learning how to be a good winner and loser are all skills that teach one how to get along with others. In addition, because the games are played in groups of two to four students, no child felt left out during game playing time. Students who normally would not choose to play together discovered by playing the card games, they could compete, learn, and have fun at the same time. In addition, students were more than willing to assist other players in their group when they required help.

This study revealed that the use of MCIP card games increased student achievement in mathematics. After further analyses of each item on the posttest, it was determined that two of the seven items accounted for the variance in performance between the control and the treatment groups. The treatment group scored significantly higher than the control group (p = .01) on Item Four, which asked students to write the fraction using numerals for three-fourths. This item was selected from the NAEP item bank and included on the
testing instrument for its ability to express student achievement as a direct result of playing "Fraction Closest to One." It would appear from the analyses, that this game does a good job of teaching fraction concepts to students.

Students in the treatment group outperformed those in the control group on Item Seven \( (p = < .05) \), which tests the concepts of chance and probability. This item was selected from the NAEP item bank for its ability to express student achievement as a result of a transfer of a learning from playing the card games. When playing card games, one intuitively knows his/her chances of attaining certain cards are increased or decreased. In this manner, it might be concluded that the MCIP card games help to teach students about probability.

Students in the treatment group outperformed control students on Items Two and Six. Item Two asks students to complete the number sentence \( 3 \times \_ = 21 \), while Item Six asks them to identify a point on a number line. Item Two was included on the testing instrument to assess the mathematical whole number concept of multiplication as a direct result of playing "Largest Product." Students used hand calculators to solve the three-digit by two-digit multiplication problems for this game, however, and did no hand calculations for any multiplication problems. As mentioned in Chapter III, this study took place during the first two months of the school year. Multiplication is generally not introduced in the third grade curriculum until the second semester. In any event, the game was not effective in teaching the whole numbers concept of multiplication, however, teachers found it to be very effective in teaching place value. Several of the teachers first introduced this game to their students by using addition. As one card at a time was drawn and called, students placed the digits in one of five
places (three-digit plus a two-digit number). The student who acquired the largest sum won the round.

After students felt comfortable playing this game using addition, teachers instructed them to multiply the factors called and to arrive at a product, using hand calculators. Students learned quickly that in order to arrive at the largest sum or product, the largest digits called needed to be placed in boxes representing the largest place value. In this manner, "Largest Product" did not teach students multiplication facts, but instead taught them the importance of place value. Students were able to arrive at multiple products by placing the digits in a variety of locations. In this manner, playing this game had multiple outcomes, for the concepts of chance and probability were also taught.

NAEP Item Six, which asks students to identify a point on a number line, was included on the testing instrument for its ability to express student achievement as a direct result from playing "Closest to Zero." This game teaches the concepts of negative and positive integers. Teachers mentioned that students had difficulty understanding how to play this game and that most found it difficult. Many of the students were unable to play the game effectively unless they had a number line in front of them. The investigator observed students in one class physically placing the cards on the number lines that they constructed and moving them to the left or to the right of zero in order to arrive at their final sum.

Pretest/Posttest Item One, which asks students to group by ten, or multiply, was solved correctly by almost all of the students. It would appear that this problem was too easy and might be considered to be an invalid test item.
Item Three on the testing instrument asks students to choose the correct number sentence for a given problem. This item was chosen for its ability to evaluate student achievement as a transfer of learning from playing the card games. There were no significant differences between groups in regard to student performance on the posttest. Apparently, this appears to be a poor choice for a test item, or perhaps the expected transfer of learning from playing the games did not occur.

Item Five asks students to find the average age of five children. This item was selected for its ability to test student achievement as a direct result from playing the statistical card game "Mean." Performance on this item was very low and results from the analyses run indicated that students might have correctly solved this problem by chance only. This might lead one to believe that this problem was an invalid test item. In a recent conversation, Dr. Ralph Tyler claimed that it is difficult to measure true learning. He stated that by using only written testing instruments to assess a child's knowledge, only a portion of his/her learning is measured. What teachers see and hear in the classroom, as well as how a child performs in class, provides a more accurate picture of what a child knows.

Though teachers stated that their students understood the mathematical concept of averaging, they did not perform well on this test item. One of the reasons may be due to the fact that three of the teachers modified the rules of the game "Mean" so their students would be able to play it. As stated earlier, third grade students are not generally introduced to multiplication, let alone division, until the second semester of third grade. The rules of this game state
that students are each dealt five cards. The student with the highest mean, or average score, wins the round. In order for their students to play the game successfully, three of the teachers used beans and small cups for manipulatives. Each student was given three small cups and a large pile of dried beans. Three cards were dealt to each student. Students added the sum of the numbers on the cards, and took an equal number of beans. Using their three cups, they placed an equal number of beans in each, until all (or almost all) of the beans were gone and each cup had an "equal share." Students in these three classes were taught that "equal share," "mean," and "average" all meant the same thing. None of the classes used all five cards to play, and the three teachers that implemented the games did so with manipulatives. One of the teachers felt the game was too difficult for her students and refused to incorporate it into her math class. According to teacher testimony, the game "Mean" helped to teach the mathematical concept of averaging effectively at the third grade level when students were able to use manipulatives to play.

Bright et al. (1985) indicated from their study that games "compensated for instructional deficiencies at the higher taxonomic levels" (p. 123). They bridged the gap in class instruction provided by the teacher. Frietag (1974) discovered in his research that "... games cannot substitute for poor teaching" (p. 120). It can be concluded from this study that teachers do make a difference. When observing total posttest scores for the treatment classes, class seven outperformed the other three classes, with class eight performing second best. Class six ranked third and class nine ranked last. This same pattern repeated itself throughout the item analyses of the posttest. In the post hoc analyses run
for the treatment classes for Items Two and Three on the posttest, classroom seven outperformed both classes six and nine at a significant level (p < .05). In classroom seven there were two teachers; the regular classroom teacher and the student teacher. Some possible conclusions might be that either the extra support the teachers in this class gave to each other while implementing the games, the effective means by which the games were presented to students, and/or the increased attention the students received from their teachers, accounted for the enhanced performance of this class. By observing the adjusted means for treatment classes on all items of the posttest, class seven ranked first on Items Two, Three, Five, and Six and ranked second on Items Four and Seven. Class eight outperformed the other three classes on Items One and Seven, and came in second on Items Three, Five, and Six. The teacher in classroom eight was in her seventh year of teaching. She motivated her children by using a variety of manipulatives, using songs and rhymes to help teach mathematical concepts, and used a number of techniques to introduce new concepts, while reviewing concepts previously learned. Her students were actively engaged in learning and what might have been routine, was fun. On one occasion, she asked students to complete a worksheet. Instead of each child doing their own, she had them moving around the classroom. After completing one problem, students moved to another worksheet, at another desk, to continue their work. Her students believed that math was fun and they always looked like they were enjoying themselves.

Students in classes six and nine consistently fell behind their peers in classes seven and eight. In fact, in regard to student performance, class nine,
taught by a first year teacher, ranked last out of the four classes on six items of the posttest, came in next to last on one item, and scored just as poorly as class six did on Item Five. Students in class six ranked first in performance on Item Four of the posttest, second on Items One and Two, third on Items Three and Seven, last on Item Six, and last again, along with class nine, on Item Five. A reason that her students did so well on Item Four, the problem which asks students to write numerals for the fraction three-fourths, might be due to the fact that this teacher did many hands-on manipulative activities with her students to introduce the fraction game "Fraction Closest to One." It can be concluded that the manner in which teachers present mathematical concepts affects the way their students learn mathematics. Had the teachers in classes six and nine been more successful in implementing the card games, the results of this study might have yielded even more significant results.

Recommendations

NCTM (1989a) states our present educational system is outdated and must change in order to meet the demands of tomorrow.

In summary, today's society expects schools to insure that all students have an opportunity to become mathematically literate, are capable of extending their learning, have an equal opportunity to learn, and become informed citizens capable of understanding issues in a technological society. As society changes, so must its schools.

(NCTM, 1989a, p. 5)

To guide this reform and assist educators with implementing change, their document, Curriculum and Evaluation Standards for School Mathematics was developed. The mathematical standards presented in this document are
considered to be basic content that should be included in all math curricula in schools across our nation. It is NCTM's (1989a) vision "that if students are exposed to the kinds of experiences outlined in the Standards, they will gain mathematical power" (p. 5). This power includes an individual's "abilities to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve nonroutine problems" (p.5). In addition, NCTM believes that mathematical power includes the "development of personal self-confidence" (p.5). It is their belief that the content area of mathematics must be expanded and expectations for student achievement must be raised. It is necessary that students become actively involved in mathematics and see the connections between mathematical concepts and their application to the real world.

Since early experiences in mathematics reflect later decisions in course taking and career choices, NCTM (1989a) believes that children should see math as exciting, creative and fun. There is a need for more interesting approaches for providing drill and practice. Parent participation is necessary so that what is learned in school can be reinforced in the home. Students need to learn to enjoy and be curious about mathematics. One of the ways to combine these ideas while implementing the Standards at the same time, is to include mathematical games in math classes. The games that were incorporated for this study meet the standards set by NCTM.

Educators have yet to fully understand the cognitive power of games in the classroom. The literature reviewed in this study described the history of games in education, instructional level of games, the cognitive effects of
implementing games in the classroom, student attitudes toward mathematics, problem solving, effective teaching of mathematics, and effective means of delivering staff development programs that implement change.

A number of studies were conducted regarding the cognitive power of implementing a variety of mathematical games into the classroom. Research has attempted to mention some ways of implementing these games effectively so students can receive the maximum benefits by playing them. Bright, Harvey and Wheeler (1980a) studied the effects of achievement grouping (heterogeneous versus homogeneous) with math concept and skill games. They concluded that the way students are grouped to play games had little to do with student learning. This conclusion supports cooperative learning research conducted by Slavin and Johnson and Johnson. Many teachers are not comfortable in a cooperative learning setting. The card games provided an easy way for them to incorporate these methods without feeling threatened.

Bright et al. (1980b) discovered that games were an effective way to maintain skills. The games they investigated were tested for their ability to retrain multiplication facts for fifth and sixth graders. The gains in achievement for the treatment group were dramatic.

Bright et al. (1981) also studied the cognitive effects of changing game rules of play. The rules included the use of manipulatives, graphic representations, or neither of these when playing games. There were no significant differences in performance between treatments on the posttest.

Generes (1977) investigated the cognitive effects of implementing an interpersonal competitive games approach with a teams-games competitive
approach. He discovered that there were no significant differences in performance on the posttest between the two approaches, for either high or low ability students.

Bright et al. (1985) studied whether games were most effective during preinstruction, coinstruction, or postinstruction. They discovered that games were very effective at the pre-instructional level at the knowledge and comprehension taxonomic levels. Games at the application stage were not as effective at this level. They concluded that students needed prior instruction in order to learn higher level material through a games approach. At the coinstructional level, knowledge and comprehension level content games were not effective. They believed that games at a higher taxonomic level than classroom instruction had the possibility of being effective since there was no classroom instruction at that level to compete with it. Classroom instruction must provide the base for learning, however, before students can handle learning higher level material. In addition, they felt that games that are at the same instructional level as the teacher's instruction are not likely to be effective.

Bright et al. (1985) concluded that post-instructional games are effective in teaching mathematical content at all taxonomic levels. They believed that games are more effective at this level than the pre- or co-instructional games because students have already been instructed with the intention of producing subject mastery.

It might be concluded that students in this study did not have the knowledge base for playing some of the games presented to them. The posttest items which showed poor performance, reflected students' inability to grasp the
mathematical concepts presented to them. Students might have made greater gains on Items Two (multiplication) and Five (averaging) had these concepts been presented at a later date or had the treatment period been extended.

Textbooks have created prejudices and seldom is anything taught in math that is not in the text. The result is a weak mathematics curriculum. Ordinarily, integers would not be taught until the sixth grade. Teachers in this study discovered that integers could be taught and understood at the third grade level. In addition, they found that averages are a part of a child's life at this level as well. The card games need to be a part of mathematics instruction, but in order for some of the concepts to be understood by children, the support of additional manipulatives is necessary.

The following recommendations are of practical significance to curriculum specialists, administrators, staff developers, math researchers, and teachers of mathematics. When incorporating games into math classes, increased student achievement might be expected if the following are considered:

1) Games that teach specific mathematical concepts can be incorporated into math classes for the purpose of teaching new concepts to students.

2) Though some games can be used to introduce ideas, most games can be used to maintain and build on skills already taught.

3) Advanced mathematical concepts can and should be introduced to all students through manipulatives. This keeps them interested, motivated, curious, and excited about mathematics.

4) Once students have been provided with a foundation for particular mathematical concepts, introducing games, manipulatives, or pictorial representations at higher taxonomic levels can increase student achievement.
5) Teachers should be provided with inservice training to assist implementation of innovative ways to incorporate the Standards effectively into their math classes and to promote change.

6) Universities and school districts should share their information and ideas.

**Suggestions for Further Research**

Because of the wide variety of math games that are available to classroom teachers today, educators must be cautious in choosing the particular games they wish to incorporate into their math classes. The games investigated for this research allowed for flexibility and could be used in a variety of ways. They provided multiple outcomes for mathematics classes.

A number of studies investigating particular mathematical games cited in the review of the literature concluded that games did not improve student achievement. Baker, Herman, and Yen (1981) discovered that the games they studied in K-3 classes appeared to be negatively related to pupil performance. Harvey, Bright, and Wheeler, 1980c, 1983, Henry, 1974, Ricks, 1983, and Wolff, 1974, concluded that the games in their studies were not effective in teaching mathematical concepts. Though Kincaid (1976) found that the games in his study did not affect student achievement in mathematics, they did produce very positive attitudes toward mathematics for the participating parents and students.

Games alone cannot teach mathematical concepts to children, but the way in which teachers present them can make a difference. With the proper support and good instructional materials, teachers can make an impact on empowering students mathematically.
Some suggestions for further research regarding the power of play in learning include:

1) The testing instrument may need to be revised. For each mathematical concept to be assessed, at least four items might be included. This might result in increased test reliability. Another alternative might be to test only one or two of the math concepts introduced through the game playing. Perhaps the instrument in this study attempted to assess too much with too little.

2) More dramatic results might have occurred had the study been conducted at the same grade level, only during the second semester, when students are introduced to multiplication and fractions. Having greater foundational knowledge in these two areas might have facilitated learning the mathematical concepts presented in some of the games.

3) Students can learn advanced mathematical concepts at an early age. In order to accomplish this, they should have the necessary knowledge base before playing math games that require them to work at higher taxonomic levels. More attention needs to be placed on teacher explanation of mathematical concepts. Perhaps a given amount of time should be devoted just to introducing new concepts, before any of the card games are played.

4) The treatment period should be increased from the eight week period. Teachers complained that trying to introduce two new games every two weeks was overwhelming. A study conducted over one school year might reduce the pressure teachers experienced, in addition to producing even more dramatic results.

5) The study should be expanded to other grade levels in order to determine whether particular card games that were included in this study have even greater potential for improving student achievement at various grade levels.

6) Attitudinal data regarding how students and teachers feel about problem solving and math should be collected from students and teachers to determine whether treatments affect the way students and their teachers feel about mathematics. Although it was not determined whether there were any significant attitudinal changes for teachers participating in this study, extending the treatment period might have a dramatic effect on the way students and teachers feel about math.

7) Additional investigations regarding the cognitive effects of implementing math games into mathematics curricula need to be conducted in other school districts across the nation in rural, suburban, and inner city
schools. Children of all ability levels need to be included in these investigations in order to determine which kinds of games can most effectively improve student achievement in various educational settings.

8) A parent component could be included when studying the cognitive effects of games. Had parents been reinforcing the math concepts by playing the games at home, the results of this study might have been even more dramatic.

**Summary**

The results of this study indicate that the MCIP card games provided an efficient, cost-effective means for increasing student achievement in math and implementing the NCTM Standards. Overall mean scores for the treatment group were significantly higher than those of the control group.

Though the experiment is over, this project continues to make an impact in the district. The investigator was asked to conduct two district inservices regarding awareness and implementation of the Standards. As a result, a number of teachers throughout the district have become interested in the card games. Teachers in the treatment group continue to use the card games with their students and believe they help them learn. Because the results from incorporating “It’s in the Cards” into math classes were so positive and students and teachers enjoyed using them, the Family Association of the two treatment schools have donated a large portion of their proceeds to purchasing math manipulatives for classroom use.

This investigation explored the cognitive effects of implementing the MCIP card games into third grade math classes. It may be determined from the results of this study that:
1) Incorporating the MCIP card games into math classes can improve student achievement in mathematics.

2) In addition to enhancing learning potential, the card games improved student interest, motivation and enjoyment of mathematics.

3) Mathematical card games can be used to introduce new mathematical concepts to children.

4) Mathematical card games can be an effective means for maintaining and practicing skills, as well as teaching students social skills.

5) "It's in the Cards" lend themselves to creative use and can be incorporated into math lessons in a variety of ways.

6) The MCIP card games provided an efficient and cost-effective means for implementing the Standards into math classes:

7) The MCIP card games investigated for this study, met a number of the mathematical standards set by NCTM. They allowed students to become actively involved in mathematics and brought technology into the classroom with the use of hand calculators. The mathematical standards they met were Standards:

   One: Problem solving
   Two: Communication
   Three: Reasoning
   Five: Estimation
   Six: Number Sense and Numeration
   Seven: Whole Number Operations
   Eleven: Statistics
   Twelve: Fractions

8) The card games introduced in this study provided an opportunity for students to study and understand advanced mathematical concepts not ordinarily included in the curriculum.

9) The games provided a link between home and school and enhanced parent involvement.
Staff development, even implemented for eight weeks, can increase student achievement in mathematics.

Throughout history, man has enjoyed playing games. Perhaps their power to teach has long been underestimated. The intent of this study was to encourage game playing in math classes in order that students would find more enjoyment, as well as achieve more in mathematics. In order to accomplish this, educators must realize the value of play in promoting problem-solving skills, interest, motivation and curiosity about mathematics. If we as educators can continue to interest and motivate students in mathematics, the students today will continue to be interested and curious about mathematics, and will pursue advanced mathematics courses in high school, college and graduate school. Hopefully, this interest, curiosity, and enjoyment for mathematics will continue to grow throughout their adult lives so that, the present national shortage of people with careers in math and science, will be replenished. As educators, we can accomplish this and can help to make math more enjoyable for adults and children alike. Instead of the burden many believe math to be, games can assist adults and children so that, increased achievement, pleasure, interest, and excitement about mathematics can make it what Merow (1990) calls a "wonderful kind of play" (p. 175).

Today, with the growing demands placed on schools and society to produce more mathematically literate graduates, and with the overburdening financial problems that face them, it becomes increasingly difficult to prepare our children for the twenty-first century.
More efficient and cost-effective ways of providing quality math programs need to be developed, so that students will be able to meet the technological society that awaits them.
REFERENCES


Meiring, S.P. (1980). *Problem solving...a basic mathematics goal.* Columbus, OH: Ohio Department of Education.


APPENDIX A
Each bag has 10 marbles in it. How many marbles are there in all?

- 10
- 15
- 25
- 140
- 150
- 160
- I don't know.

$3 \times \square = 21$

What number should go in the $\square$ to make this number sentence TRUE?

ANSWER________
Sam has 68 baseball cards. Juanita has 127. Which number sentence could be used to find how many more cards Juanita has than Sam?

- $127 - 68 = \underline{}$
- $127 + \underline{} = 68$
- $68 - \underline{} = 127$
- $68 + 127 = \underline{}$
- I don't know.

Write this fraction using numerals.

three-fourths

ANSWER

Here are the ages of five children:

13, 8, 6, 4, 4

What is the average age of these children?

- 4
- 6
- 7
- 8
- 9
- 13
- I don't know.
Which of the following is shown by the number line?

- $a = b$
- $a < b$
- $a > b$
- Can't tell anything about $a$ and $b$
- I don't know.

There is only one red marble in each of the bags shown below. Without looking, you are to pick a marble out of one of the bags. Which bag would give you the greatest chance of picking the red marble?

- Bag with 10 marbles
- Bag with 100 marbles
- Bag with 1000 marbles
- It makes no difference.
APPENDIX B
PRE/POST SURVEY

TEACHER:

SCHOOL:

CONTROL/TREATMENT

Please circle the appropriate response to the following questions:

1. How important is it to follow the order of the mathematics textbook in planning and teaching mathematics?

Very Important Important Undecided Not important Not at all important

1 2 3 4 5

2. Do you use manipulative activities in your math lessons?

YES NO

How often per week?

1 day 2 days 3 days 4 days 5 days

3. How important is it to teach INTEGERS? (negative nos. included)

Very Important Important Undecided Not important Not at all important

1 2 3 4 5

4. How difficult is it to teach INTEGERS?

Very Easy Easy Undecided Hard Very Hard

1 2 3 4 5

5. How much do you like teaching INTEGERS?

Like a lot Like Undecided Dislike Dislike a lot

1 2 3 4 5
6. How important is it to teach STATISTICS?  
<table>
<thead>
<tr>
<th>Very Important</th>
<th>Important</th>
<th>Undecided</th>
<th>Not important</th>
<th>Not at all important</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

7. How difficult is it to teach STATISTICS?  
<table>
<thead>
<tr>
<th>Very Easy</th>
<th>Easy</th>
<th>Undecided</th>
<th>Hard</th>
<th>Very Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

8. How much do you like teaching statistics?  
<table>
<thead>
<tr>
<th>Like a lot</th>
<th>Like</th>
<th>Undecided</th>
<th>Dislike</th>
<th>Dislike a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

9. How important is it to teach FRACTIONS?  
<table>
<thead>
<tr>
<th>Very Important</th>
<th>Important</th>
<th>Undecided</th>
<th>Not important</th>
<th>Not at all important</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

10. How difficult is it to teach FRACTIONS?  
<table>
<thead>
<tr>
<th>Very Easy</th>
<th>Easy</th>
<th>Undecided</th>
<th>Hard</th>
<th>Very Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

11. How much do you like teaching FRACTIONS?  
<table>
<thead>
<tr>
<th>Like a lot</th>
<th>Like</th>
<th>Undecided</th>
<th>Dislike</th>
<th>Dislike a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

12. How important is it to use MATH GAMES?  
<table>
<thead>
<tr>
<th>Very Important</th>
<th>Important</th>
<th>Undecided</th>
<th>Not important</th>
<th>Not at all important</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

13. How difficult is it to use MATH GAMES?  
<table>
<thead>
<tr>
<th>Very Easy</th>
<th>Easy</th>
<th>Undecided</th>
<th>Hard</th>
<th>Very Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
14. How much do you like teaching MATH GAMES?

<table>
<thead>
<tr>
<th>Like a lot</th>
<th>Like</th>
<th>Undecided</th>
<th>Dislike</th>
<th>Dislike a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

15. At what grade level would you recommend the following math topics be introduced? (Circle appropriate grade for each topic)

<table>
<thead>
<tr>
<th>Topic</th>
<th>K</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Integers</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Probability</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Statistics</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Coordinate Geometry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Data Collection</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Whole Numbers</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Ratios and Percents</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Fractions</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Graphing</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Math Games</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>
16. Indicate which topics you introduced to your students last year with a check mark and which topics you plan to introduce during the coming school year with an X. What grade level did you teach last year? _____________

<table>
<thead>
<tr>
<th>Topics introduced to students last year ( )</th>
<th>Topics you plan to introduce this new school year (X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra</td>
<td>( )</td>
</tr>
<tr>
<td>Integers (negative)</td>
<td>( )</td>
</tr>
<tr>
<td>Probability</td>
<td>( )</td>
</tr>
<tr>
<td>Statistics</td>
<td>( )</td>
</tr>
<tr>
<td>Coordinate Geom.</td>
<td>( )</td>
</tr>
<tr>
<td>Data Collection</td>
<td>( )</td>
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<tr>
<td>Whole Numbers</td>
<td>( )</td>
</tr>
<tr>
<td>Ratios and Percent</td>
<td>( )</td>
</tr>
<tr>
<td>Fractions</td>
<td>( )</td>
</tr>
<tr>
<td>Graphing</td>
<td>( )</td>
</tr>
<tr>
<td>Math Games</td>
<td>( )</td>
</tr>
<tr>
<td>Computer software</td>
<td>( )</td>
</tr>
<tr>
<td>Use of learning center to integrate reading materials with math</td>
<td>( )</td>
</tr>
</tbody>
</table>

17. As result of learning the MCIP card games, do you use more, the same or less of the following:

CLASSROOM DISCUSSION MORE SAME LESS
COOPERATIVE LEARNING MORE SAME LESS
WORKSHEETS MORE SAME LESS
DRILLING ACTIVITIES MORE SAME LESS
CALCULATORS MORE SAME LESS
PROBLEM SOLVING MORE SAME LESS
TEXTBOOK MORE SAME LESS
MANIPULATIVES MORE SAME LESS

18. Additional Comments:

THANK YOU VERY MUCH!
STUDENT EVALUATION - MCIP CARD GAMES

SEX: M  F

MATH TEACHER:

Your teacher used some mathematical card games to help teach math this fall. They were:

Combinations of Ten
Peace
Go for Zero
Sum 29
Mode
Median
Mean
Fraction Closest to 1
Largest Product

1. Which card game did you enjoy playing the most? Why?

2. Which of the other card games did you enjoy playing? Why?

3. What new card games did you or your teacher create from the ones above?

4. Did you play the card games at home? If so, who did you play with? About how often did you play the games?
5. Did you teach anyone else the card games? Who?

6. How do you think the games helped you?

7. Was there anything you didn’t like about playing the games?

Additional comments:
MCIP CARD GAMES - TEACHER EVALUATION

This fall you received materials, information, and training to help teach mathematical concepts using card games. The games were:

- Combinations of Ten
- Peace
- Sum 29
- Go for Zero
- Mode
- Median
- Mean
- Fraction closest to one
- Largest product

1. How did your students benefit by playing the games?

2. What problems did you encounter implementing the games?

3. Which games were most liked by your students? What were their reasons for liking them?

4. Which games did your students dislike? What were their reasons?
5. What parent feedback, if any, did you receive regarding the games?

6. What were the benefits of the workshops?

7. What were the benefits of the videotaping?

8. How can the program be improved?

9. Would you recommend that this staff development be expanded to other grade levels? If so, which ones?

10. Additional Comments:
APPENDIX C
IT'S IN THE CARDS!

MATH CARD GAMES

INSTRUCTION MANUAL

Developed by:

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GENERAL RULES

MATERIALS: Decks of cards with all face cards removed.

RULES:

1. No picture cards are used. Aces = 1. All other cards are face value.

2. To determine the dealer each player draws a card from the deck. High card determines the dealer. The dealer goes first and play proceeds to the left. The next deal also proceeds to the left.

3. Each game is played for a maximum of 10 minutes.

4. The player with the most points at the end of the game wins. All winning hands must be proved verbally and visually.

5. If a tie occurs, both players win.

6. Games are played with two to four players.

COMBINATIONS OF TEN

MATH CONCEPT: Whole Numbers

OBJECT OF THE GAME: To make combinations of 10 using one or two cards. Combinations may be two black cards, two red cards, a red and a black card, or the 10 card alone.

RULES:

1. Deal 10 cards to each player.

2. Players make as many combinations of 10 as possible using the cards that were dealt to them.

3. Players place their combinations of 10 on the playing area in front of them.

4. The player(s) with the most combinations win(s) 1 point.

5. The player(s) with the most points at the end of 5 games win(s).
OBJECT OF THE GAME: To be the player who has the highest sum at the end of the game.

RULES:

1. Deal 6 cards to each player.

2. Each player turns two cards face up and adds them together. The players with the highest sum gets all the cards and places them in his/her discard pile.

3. If a tie occurs, players put their cards in their own discard pile.

4. The game continues until all cards have been turned over.

5. Each player then counts the cards in his/her discard pile.

6. The player(s) with the most cards win(s) 1 point.

7. The player(s) with the most points at the end of 5 games win(s).
SUM 29

MATH CONCEPT: Whole Numbers

OBJECT OF THE GAME: To be the player who makes the sum 29.

RULES:

1. Deal 4 cards face up to each player and place 1 card face up in the middle of the playing surface.

2. Each player in turn selects 1 card from his/her hand and places it next to the card(s) in the middle of the playing surface.

3. The player adds this card value to the value of the card(s) on the playing surface trying to attain the sum of 29.

4. The player then replaces his/her card with the one from the deck.

5. If a player does not have a card that when added to the sum will equal 29 or less he/she forfeits the game.

6. The player to reach the sum of 29 is the winner and wins 1 point.

7. If all players forfeit, the game is a draw and no points are awarded.

8. The player(s) with the most points at the end of 5 games wins.
GO FOR ZERO

MATH CONCEPT: Integers

OBJECT OF THE GAME: To be the player with the combination closest to zero.

Red cards = negative values.

Black cards = positive values.

RULES:

1. Deal 3 cards to each player.

2. Each player combines 2 of the 3 cards to make a combination that is the closest to zero. The combination may have a negative, positive, or zero value.

3. The player(s) with the combination closest to zero win(s) 1 point.

4. The player(s) with the most points at the end of 5 games win(s).
MATH CONCEPT: Statistics

GRADE LEVEL: 3,4

# OF PLAYERS: 2-4

OBJECT OF THE GAME: To be the player that has the greatest number of cards of the same value in his/her hand.

RULES:
1. Deal 5 cards to each player. (You can vary the number to be dealt to have students learn how their chances of obtaining 3 of the same card will increase, if given more cards.)
2. Each player orders his/her cards.
3. Each player in turn shows his/her cards and states their mode. (number occurring most often)
4. The player(s) with the greatest number of the same card wins 1 pont.
5. The player(s) with the most points at the end of 5 games win(s).

EXAMPLE: 1 2 3 3 4  Mode = 3 Since the player with the
1 2 2 2 9  Mode = 2  mode=2 has 3 cards of the same value, they win the game.
MEDIAN

MATH CONCEPT: Statistics

OBJECT OF THE GAME: To be the player that has the highest median (middle value - not the average value) value in his/her hand.

RULES:
1. Deal 5 cards to each player.
2. Each player orders his/her cards.
3. Each player in turn shows his/her cards and states the median value.
4. The player(s) with the highest median win(s) 1 point.
5. The player(s) with the most points at the end of 5 games win(s).

EXAMPLE: 1 2 3 3 4 Mode
EXAMPLE: 1 2 3 4 7 Median = 3 1 1 4 7 8 Median = 4
1 2 2 5 9 Median = 2 1 4 5 7 8 Median = 5

MEAN

MATH CONCEPT: Statistics

OBJECT OF THE GAME: To be the player with the highest mean (average score) in his/her hand.

RULES:
1. Deal 5 cards to each player.
2. All cards have absolute value.
3. Each player adds the value of his/her 5 cards and divides by 5 to get the mean value of the hand. Fractions should be expressed in fifths.
4. The player(s) with the highest mean value win(s) 1 point.
5. The player(s) with the most points at the end of 5 games win(s).
FRACTION NEAREST TO 1

MATH CONCEPT: Fractions

OBJECT OF THE GAME: To be the player with the fractions that is the closest to 1.

RULES:
1. Deal 3 cards to each player.
2. Each player uses 2 of the 3 cards to make a fraction with a value that is the closest to 1. The fraction may be greater than, less than, or equal to one.
3. The player(s) with the value closest to 1 win(s) 1 point.
4. The player(s) with the most points at the end of 5 games win(s)

LARGEST PRODUCT

MATH CONCEPT: Whole Numbers

OBJECT OF THE GAME: To be the player that places the card values on his/her score sheet in such a way as to attain the largest product.

RULES:
1. Give each player a LARGEST PRODUCT worksheet.
2. 10 is given a value of 0 for this game.
3. The dealer turns over 5 cards, one at a time in the middle of the playing surface.
4. As each card is shown, the players place the card value in one of the 5 spaces on their worksheet.
5. After all 5 cards are shown, each player multiplies his/ her values.
6. The player(s) with the largest product win(s) 1 point.
7. The player(s) with the most points at the end of 5 games win(s).
The dissertation submitted by Marsha Anne Hestad has been read and approved by the following committee:

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The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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