STUDENT ACHIEVEMENT AND TEACHER TRAINING IN THE *OPENING EYES TO MATHEMATICS* PROGRAM

by

LYNDA ANN EAST LUCKIE

(Under the Direction of Dr. C. Kenneth Tanner)

ABSTRACT

The purpose of this study was to determine if there is a significant difference in the class average achievement scores of two groups of teachers when one group participated in the Opening Eyes to Mathematics (OEM) professional development training and the other group did not. The class average achievement data were collected on the total mathematics section of the Spring 2003 administration of the fourth grade Georgia Criterion Referenced Competency Test (CRCT). The study took place in a large suburban district in the southeast and the sample consisted of 90 teachers, 45 of whom had not received OEM training and 45 of whom had received the training. The dependent variable was the achievement data and the independent variable was the presence or absence of OEM training of the teachers. Descriptive statistics, a Levene Test of Homogeneity of Variances, and a t-test were performed to determine the level of significance.

The findings of the study showed a statistically significant difference in the average class scores in mathematics achievement between teachers who have been trained in OEM and those who have not. The data showed that class average scores for teachers who were trained were higher than class average scores for teachers who were not trained. The Levene Test of Homogeneity of Variances verified the assumption of equality of variances across the groups.

INDEX WORDS: Opening Eyes to Mathematics program, Criterion Referenced Competency Test (CRCT), The National Assessment of Educational Progress (NAEP), National Council of Teachers of Mathematics (NCTM), School Administrative Student Information (SASI), Student Assessment Reporting Tool (StART), Third International Mathematics and Science Study (TIMSS)

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DEDICATION

For each of us, there is that handful of people upon whom we depend for their wisdom, guidance, friendship and support. This dissertation is dedicated to that handful. My parents always advised, “If it’s worth doing, it’s worth doing right,” and that advice has been ingrained into my subconsciousness. They never allowed me to believe there was something I couldn’t accomplish. For their faith in me and their unconditional love, I am forever grateful.

My two daughters, Michelle and Heather, two of my closest friends, have offered continued words of encouragement and support. Without them, I would never have known the joys of being a mother who has come full circle into deep friendship with her children. The three of us are members of a mutual admiration society. This is the richest of blessings.

For those dear, dear friends who have traveled this road before and alongside me, I salute you and celebrate with you. Thank you Dot, Rita, Patty, Lea, and Diane. You have taught me much about life, priorities and how to survive it all.

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CHAPTER I

INTRODUCTION

Introduction

"Many who have never had the occasion to discover more about mathematics confuse it with arithmetic and consider it a dry science. In reality, however, it is a science which demands the greatest imagination" (Retrieved February 17, 2004 from the World Wide Web: wysiwyg://107/http://www.edenpr.k12.mn.us/learn/research.html, ND).

Sofia Kovalevskaya

19^{th} Century Russian mathematician

It all began with Sputnik. The successful launch of the Russian spacecraft in 1957 created a sense of urgency within the American academic community. There was much interest in reforming schools so that America could compete more effectively with the well-educated engineers is the USSR. Catching up with the Russians became a national obsession. A flurry of new curriculum materials was developed during the 1960s to address this need (Schlechty, 2001). Jerome Bruner contended that the best way to improve education was to develop new and sophisticated materials and to properly engage students so they could learn at some level what scholars in the various disciplines knew (Bruner, 1966).

Despite these efforts, today's students are often falling short in preparation for the job market.

> Students who attend America's high schools today are generally further from meeting citizen and employer expectations than was the case for students fifty years ago, even though today's students in general are probably academically more well prepared than were past generations. (Schlechty, 2001, p. 36)

In *Before It's Too Late*, a report from the National Commission on Mathematics and Science Teaching for the 21st Century, Commission Chairman John Glenn stated,

> First, at the daybreak of this new century and millennium, the Commission is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically.
>
> From mathematics and the sciences will come the products, services, standard of living, and economic and military security that will sustain us at home and around the world. From them will come the technological creativity American companies need to compete effectively in the global marketplace. 'Globalization' has occurred. Economic theories of a few years ago are now a reality. (Glenn, 2000, p. 4)

America continues its quest to appropriately and adequately educate our students. Significant legislation has been put into place that specifically addresses these goals. On January 8, 2002, President Bush signed into law the federal *No Child Left Behind Act of 2001*. Among other important features, this legislation dictates that states should publish achievement results separately for racial and ethnic groups and work to alleviate intergroup disparities. Thus, for the first time in the nation's history, raising achievement levels among racial and ethnic minorities and closing achievement gaps are explicit goals of federal policy. Achievement scores are now a matter of individual accountability.

Statement of the Problem

Mathematical knowledge has exploded over the past 50 years, both in its pure sense and its relationship to science and technology. Yet, we tend to think of the academic content of the mathematics curriculum as essentially static. It is very rare to encounter a student who has ever calculated a square root by hand or who has ever seen or used a slide rule (Smith, 2001).

With increased mathematical knowledge and the infusion of technology to support it, the quality of mathematics instruction has not generally kept pace with the content. "Traditional mathematics teaching … is still the norm in our nation's schools. For most students, school mathematics is an endless sequence of memorizing and forgetting facts and procedures that make little sense to them" (Battista, 1999, p 426). As a result, American students continue to feel the consequences of yesterday's teaching methods.

Recent reports of the performance of America's students in mathematics from both the Third International Mathematics and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP) echo a dismal message of lackluster performance (Before It's Too Late, 2000).

The National Council of Teachers of Mathematics (NCTM) has now published four major documents that offer a significantly broadened view of the nature of mathematics, what it means to know mathematics, how students can learn mathematics, and what kinds of teaching practices best foster this learning. These documents include *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), *Assessment Standards for School Mathematics* (1995), and the *Standards 2000* document, a revision of the original 1989 curriculum and standards document. These standards documents are available at the NCTM website www.nctm.org.

As part of the 1996 NAEP, teachers were asked about their knowledge of the 1989 National Council of Teachers of Mathematics (NCTM) Standards. The teachers of 46% of fourth graders professed little or no knowledge of the standards and only 5% of the fourth graders had teachers who indicated that they were very knowledgeable. In contrast, only 19% of the eighth graders had teachers who claimed to have little or no knowledge of the standards, and 16% had teachers claiming to be very knowledgeable (Hawkins, Stancavage, & Dossey, 1998).

Virtually every state within the United States embraces the NCTM standards as its state curriculum is developed. A knowledge and understanding of these standards is inextricably connected to efforts to improve instruction and increase student achievement. The far-reaching ideas in these documents have stimulated the development of many new curriculum programs funded by the National Science Foundation. Moreover, most commercial publishers of mathematics textbooks have incorporated these standards into their latest editions.

The Georgia Quality Core Curriculum (QCC) is directly aligned with the curriculum standards proposed by NCTM. Although the curriculum for our state is aligned with these national standards, Georgia's elementary and middle school students fall short of the national average in math and science achievement, according to test scores from the National Assessment of Educational Progress (NAEP). In 2000, 42% of Georgia's fourth-graders operated below basic math proficiency, compared with 33% nationwide (National Center for Education Statistics, 2001).

As schools and districts continue their efforts to close the achievement gap and increase the quality of mathematics education, a great deal of attention has been given to teacher preparation and professional development. Much has been written about factors that influence student achievement.

Marzano (2003) states that in terms of student achievement, the impact of decisions regarding instruction made by individual teachers is far greater than the impact of decisions made at the school level. Given this research, how can we use it to improve student achievement? While individual teachers are necessarily influenced by decisions made by the school, teacher-level factors are a powerful influence on student learning. These factors include, but are not limited to, instructional strategies, classroom management, and classroom curriculum design (Marzano, 2003). Wright, Horn & Sanders (1997) noted that the teacher is the most important factor affecting student learning. They suggested that seemingly more can be done to improve education by improving the effectiveness of teachers than by any other single factor. Effective teachers appear to be effective with students of all achievement levels regardless of the levels of heterogeneity in their classes (Wright, Horn, & Sanders, 1997).

Brophy and Good (1986) argue that teaching is a form of expert work that requires extensive professional preparation, strong subject matter knowledge, and a variety of pedagogical skills, all of which are drawn upon within the dynamics of classrooms. There may also be other factors present that influence the interactive part of teaching such as teachers' appearance, enthusiasm, intelligence, and leadership. Effective teachers are active teachers. Active teaching occurs when teachers spend more time in direct interaction with students. This interaction can involve lectures, demonstrations, leading discussions, and frequent conversations with students during seatwork assignments as contrasted with a teaching style in which students frequently work independently on academic tasks, are engaged in nonacademic work, or both. Active teaching also involves good classroom management skills such as consistent enforcement or rules and quick responses to disruptions. (Brophy & Good, 1986).

Speaking for the National Commission on Mathematics and Science Teaching, John Glenn (2000) stated,

> We are of one mind in our belief that the way to interest children in mathematics and science is through teachers who are not only enthusiastic about their subjects, but who are also steeped in their disciplines and who have the professional training – *as teachers* (emphasis original)- to teach those subjects well. Nor is this teacher training simply a matter of preparation; it depends just as much – or even more – on sustained, high-quality professional development (p. 5).

This high-quality professional development for teachers can be a key factor in the academic success of students. If an effective teacher is defined as a teacher whose students score well academically on standardized assessments, patterns may be present among effective teachers that can be identified in terms of a professional profile. Those patterns can be evidenced in such areas as professional development, experience, content knowledge, expectations of students, and instructional practices.

Purpose of the Study

The researcher focused on one specific professional development opportunity for teachers and whether or not it made a difference in their students' mathematics achievement scores. *Opening Eyes to Mathematics* is a curriculum program that was developed with partial funding from the National Science Foundation. Originally developed in the early 1980s by the Math Learning Center at Portland State University in Portland, Oregon, this program targets mathematics instruction to third and fourth grade students. At its core is a constructivist-based philosophy of learning for children. There is no textbook and correlated set of worksheets. Rather, it is a hands-on, interactive, discovery of mathematical concepts presented in lessons that were developed to encourage children to think visually and represent their learning with words and pictures as well as numbers. Teachers who use this program receive a 30-hour training that involves not only a different way of teaching for some, but also a rediscovery of content that often fosters mathematical understanding on a new level for teachers.

The researcher examined average class scores in mathematics for groups of fourth grade students in a large suburban school system in the southeastern United States. These average class scores were collected for two groups of teachers: one group participated in the *Opening Eyes to Mathematics* professional development and the other group did not participate in this learning. Specifically, average class scores on the total mathematics portion of the fourth grade Georgia Criterion Referenced Competency Test (CRCT) were examined for the two groups of teachers for the 2002-2003 school year.

The focus of this study was to determine whether or not there is a statistically significant correlation between teachers who have been trained in *Opening Eyes to Mathematics* and their students' mathematics achievement scores as compared to the mathematics achievement scores of students whose teachers have not been trained in this program.

If differences exist between student achievement and teacher training in *Opening Eyes to Mathematics*, it would suggest implications for teacher development and for identifying those teachers whose students may have a greater probability of scoring well on assessments.

Research Question

The basic research question for this study was: Does teacher professional development in the *Opening Eyes to Mathematics* program impact student achievement in fourth grade mathematics?

Significance of the Study

In a national effort to catch up with the Russians in the space race, the United States displayed an intensity to improve math and science education. We caught up, indeed, and first reached the moon. However, the US did not maintain nor duplicate that academic intensity over time, as witnessed by results from TIMSS and NAEP.

With the passage of the federal *No Child Left Behind Act of 2001*, Congress fundamentally redefined what it means to be a successful school. Schools will be judged not only on their average standardized test scores, but also on their ability to improve achievement among all groups of students. Hence, the term "achievement gap" has taken on a much more significant meaning.

Sanders claimed that differences in the effectiveness of individual classroom teachers are the single largest contextual factor affecting the academic growth of students (Sanders, 1998).

The impact of decisions regarding instruction made by individual teachers is far greater than the impact of decisions made at the school level (Marzano, 2003). While individual teachers are necessarily influenced by decisions made by the school, teacher-level factors are a powerful influence on student learning. These factors include, but are not limited to, instructional strategies, classroom management, and classroom curriculum design.

Teacher expectations of how well students will perform is another factor in student learning and can significantly contribute to the achievement gap among some groups of students. Poor and minority students are taught disproportionately by inexperienced and poorly prepared teachers. These students are not held to high expectations and are generally given assignments that represent lower standards than those given to other students (Haycock & Jerald, 2002).

As schools continue to strive to close the achievement gap and avoid the dreaded "list" of schools not making Adequate Yearly Progress (AYP) defined within the *No Child Left Behind Act of 2001*, increased attention should be paid to maintaining a focus on effective teaching and learning. The basic teaching style in many math classes remains essentially what it was two generations ago. By contrast, teaching innovation and higher student performance are well documented in other countries, where students' improvements are anchored to an insistence on strong professional development for teachers (Before It's Too Late, 2000).

This study examined one professional learning opportunity for teachers and whether or not implementation of this new learning within the classroom made a difference on average class scores in mathematics on the Georgia CRCT. Two groups of teachers were examined, one group with training in *Opening Eyes to Mathematics* and one group without this training. Teachers from each group were randomly selected and their class averages for mathematics were examined and compared.

When the data for any given professional learning are examined, decisions can be made regarding its value. With increased budgetary restraints, school systems must make careful decisions about which professional development programs are selected to enhance teacher effectiveness and effectively strive to close the achievement gap within the district. Language Arts and Mathematics are the two focus areas for determining annual yearly progress (AYP) for local schools and are areas of great concern for teachers, building principals and district curriculum personnel. Based on research supporting the notion that teachers are the single most influential factor in student achievement, the logical assumption is that school districts need to explore every avenue possible to develop the quality of teachers. Because this study revealed that teachers who have been trained in *Opening Eyes to Mathematics* have class averages that reflect higher levels of math content acquisition than those teachers who have not been trained, then it is incumbent upon the system to create additional staff development initiatives that support this program. This information is also useful to principals as they hire teachers for their buildings. Professional development transcripts could be examined to determine whether or not the applicant has completed this training that is a potential indicator of success for students. Individual teachers can use this knowledge as they define and refine their own personal goal setting process. Teachers in this district are responsible for developing annual goals based on their school's goals. A part of this process includes personal goals for improvement that could be enhanced by meaningful professional development opportunities.

Assumptions of the Study

- Teachers who have participated in *Opening Eyes to Mathematics* professional learning implemented the philosophy of the program.

- All teachers within the school district had the same opportunities for professional development.
- The same teacher was with students the entire year for which data were collected.
- Class sizes for all teachers in the study were about the same.
- Classroom teachers were not likely to have changed their teaching practices during the time data were collected.

Limitations of the Study

- The study included class averages of 45 teachers who have been trained in the *Opening Eyes to Mathematics* program and 45 teachers who have not received the training.
- The study collected class average mathematics achievement data for both sets teachers and compared them.
- Fidelity of implementation of the training cannot be controlled by the researcher.
- All teachers were fourth grade teachers within the district.
- All class averages of mathematics achievement data were reported by the SASI and StART data reporting systems used by the district.

Definition of Terms

CRCT

Criterion Referenced Competency Test – An assessment mandated by the state of Georgia. This assessment is administered to students in grades 1-8 annually and is designed to become promotion criteria for designated grade levels.

NAEP

The National Assessment of Educational Progress reports have been published by the US government since the 1990s and yield a variety of statistics regarding academic achievement and trend data.

NCTM

National Council of Teachers of Mathematics – A national, non-profit organization that has developed a set of national curriculum, professional, and assessment standards for the teaching and assessment of mathematics instruction.

Manipulatives

Manipulatives can be defined as concrete objects used by students and teachers to teach and learn mathematical concepts. They can include commercial and non-commercial items. For example, students can use paper clips to measure the perimeter of a textbook in non-standard units. Commercially manufactured pattern blocks can be used to teach geometric concepts, fractions, perimeter and area.

Preservice teachers

Preservice teachers is a term that refers to students who are enrolled in college or university programs designed to prepare them for teaching.

SASI

SASI is an acronym for School Administrative Student Information, an extensive database housing information about students, assessment, discipline records and a host of other information related to students and their school experience in the district.

StART

StART is an acronym for Student Assessment Reporting Tool. It is a large database developed for the district and includes information on students and their academic records. Data are entered for standardized assessment scores as well as class and school demographics. Specific reports can be created for dozens of purposes such as strand data within the mathematics assessments for the system for any given year of administration.

TIMSS

The Third International Mathematics and Science Study was completed in 1995. It compared the mathematics achievement of students in 41 countries. The Third International Mathematics and Science Study – Repeat (TIMSS-R) was completed in 1999.

Research Design

The research design was descriptive statistics study that compared mathematics achievement data as reported by class averages between two groups of teachers. The dependent variable was class average achievement scores in mathematics on the 2003 administration of the fourth grade CRCT. The independent variable was whether or not teachers have been trained in *Opening Eyes to Mathematics.*

The population for this study included all fourth grade teachers in the district. The sample size was 45 teachers who have been trained in *Opening Eyes to Mathematics* and 45 teachers who have not participated in the training, a total of 90 teachers. Classes were heterogeneously mixed and balanced according to ethnicity and socioeconomic status as determined by verification by query on the district's School Administrative Student Information (SASI) and/or Student Assessment Reporting Tool (StART) data.

In addition, all teachers were fourth grade teachers from schools with similar demographics and class size did not exceed 30 students. ALL students, including ESOL and Special Education students, were included in the class average achievement scores.

Descriptive statistics and a t-test were utilized in examining these data. Additionally, a Levene Test of Homogeneity of Variances was completed to determine validity of the assumption of equal variances.

A significance level of $\alpha = 0.05$ was used for this study. This value helped the researcher determine acceptance or rejection of the null hypothesis.

The null hypothesis in this research was that there is no difference in average class scores for teachers who have been trained in *Opening Eyes to Mathematics* as compared to average class scores for teachers who have not received this training.

CHAPTER TWO

REVIEW OF THE LITERATURE

Introduction

Teachers whose students are immersed in a productive learning environment and, consequently, score well on standardized assessments may share common professional traits. Those commonalities may be connected in some way to an awareness of mathematics achievement in the United States as compared to other nations and the associated achievement gaps within those achievement levels. These teachers may also know about and incorporate research-based best practices within their classrooms, using manipulatives and concrete models along with active student engagement. Preservice training and attitudes about student learning can be key elements in the definition of effective teachers. Effective professional development and its implementation is a high priority for many teachers and school districts,

Several questions emerged related to this research. The subquestions included:

- How does the mathematics achievement of students in the United States compare with that of other countries and is there a need for academic improvement in mathematics?
- What factors are generally associated with the achievement gap and what are recommended strategies for closing the gap?
- What are best practices in mathematics education? What instructional strategies are most effective?
- How should manipulatives and concrete models be used in the elementary classroom and does using them make a difference in student learning?

- What are important elements of effective professional development?
- How effective is the mathematics training that preservice teachers in the elementary classroom typically experience and does it affect the way they teach?
- Do teacher attitudes and perceptions make a difference in student learning?

The literature reviewed supported the efforts to answer some important questions related to effective teachers. What does the research say about how students in the United States perform mathematically as compared to students in other nations? What do the NAEP and TIMSS say about student achievement? The *No Child Left Behind Act of 2001* mandated that states report student achievement among all groups of students and that the achievement gap that exists between those groups is to be closed. What does research say about the achievement gap and how it can be closed? As we strive to close the achievement gap, what are identified best practices in educating children? What about student engagement? What part does the use of manipulatives play in the mathematics learning of children? How is effective professional development described and how should it be structured? Are our new teachers adequately prepared to teach mathematics in today's classroom, given heightened demands on student understanding and achievement?

TIMSS Report and NAEP

The National Assessment of Educational Progress (NAEP) reports have been administered since the 1990s and include two separate components for mathematics: the main NAEP and long-term trend NAEP. The 1996 mathematics assessment is the most recent main assessment to be thoroughly analyzed. Across grades 4, 8 and 12, only 45 % of students were at the level of basic achievement that was denoted as partial mastery of knowledge and skills that are fundamental for proficient work. Another 35% of students were below the basic level of achievement. Only 21% of fourth graders and 24% of eighth graders were at or above the proficient level. Although the achievement scores were low, the main NAEP assessments show that from 1990 to 1996, there have been significant gains of about one grade level (Dossey, 2000).

In 1995, the Third International Mathematics and Science Study (TIMSS) assessed the performance of students in 41 nations. Of the 26 nations participating at the elementary level, children in the United States were among the leaders in the fourth-grade assessment, scoring above the international average in math and science, but still significantly below the levels of the top-performing countries (the top four countries were Singapore, Korea, Japan, and Hong Kong). Of the 41 participating countries at the eighth-grade level, the assessment showed US students scoring slightly above the international average in science and slightly below in mathematics. By high school graduation, US students were among the last in the rankings. In fact, among 20 nations assessed in advanced mathematics, none scored lower than the US. (Third International Mathematics and Science Study, 1995). This is evidence of the fact that our children have fallen behind and are not world-class learners when it comes to mathematics and science.

American students were twelfth among 26 nations in fourth grade, twenty-eighth among 41 nations in eighth grade, and twelfth graders were tied for eighteenth among 20 nations. Students were not assessed from the same number of nations in all grades (Kearns & Harvey, 2000).

The results from the TIMSS have been widely reported in the media and have caught not only the attention of the educational community, but also the attention of politicians, policy makers, and the general public. The countries participating in the TIMSS study vary in many respects – educationally, socially, economically, historically, and culturally. Although the study has been an important piece of documentation, the TIMSS cannot provide evidence that any one single practice is responsible for higher mathematics achievement in one country than in another (Kilpatrick, Swafford, & Findell, 2001).

The Third International Mathematics and Science Study – Repeat (TIMSS-R) was completed in 1999 and is a successor to the 1995 TIMSS. It focused on the mathematics and science achievement of eighth grade students in 38 participating nations. Between 1995 and 1999, there was no significant change in the mathematics achievement of U.S. eighth graders. US eighth grade students outperformed their peers in 17 nations, performed similarly to their peers in 6 nations, and performed lower than their peers in 14 nations in 1999 (Third International Mathematics and Science Study – Repeat, 2001).

Achievement Gap

The *No Child Left Behind Act of 2001* mandated that schools will be held accountable for their standardized test scores and for improvement in academic achievement among all groups of students. School boards and local education agencies are directing schools to develop plans that address the federally mandated description of a successful school. The achievement gap is no longer just an issue of educational importance. It has become a political one as well.

Most other nations have a national education system in place that can change direction more rapidly than our K-12 system, which is operated by nearly 16,000 independent school boards. Even when the majority of board members are firmly dedicated to good education, it is still a difficult job to change direction when needed (Glenn, 2000).

The achievement gap is not a new phenomenon. For more than a generation, we focused on improving the education of poor and minority children and made real gains. Between 1970 and 1988, the achievement gap between African American and white students was cut in half and the gap separating Latinos and whites declined by one-third. That progress came to a halt in 1988 and since that time, the gaps have widened (Haycock, 2001).

The mathematics achievement gap among 13-year-old African American and Latino students reached its narrowest point from 1990 – 1992 and the gaps widened thereafter. In 1999, by the end of high school, about 1 in 100 African American students and 1 in 30 Latino students could comfortably do multi-step problem solving and elementary algebra, compared to about 1 in 10 white students. Only 3 in 10 African American and 4 in 10 Latino 17-year-old students had mastered the usage and computation of fractions, percents and averages, compared to 7 in 10 white students. Most alarming is the statistic that by the end of high school, African American and Latino students had skills in mathematics that were at the same level as those of white students in 8th grade (National Center for Education Statistics, 2001).

In fourth grade mathematics, nearly two out of three African American and one in two Hispanic students performed below the basic level, compared to one in five white students. By eighth grade, when these students had mastered the basic skills, their peers had made much greater progress. By the end of high school, these African American and Hispanic students generally performed at about the same level as eighth graders (Haycock & Jerald, 2002).

The 2003 national profile of students taking the SAT showed exam scores that revealed the gap between black and white students. African American or black mean scores on the mathematics portion were 426 as compared to 534 for white students, a gap of 108 points. The average score among the Hispanic groups was 458, showing a gap of 76 points.

The achievement gap is difficult to close and represents a multi-dimensional problem. Many poor and minority children enter school already behind, given their lack of experiences that would be conducive to learning. Moreover, many high-poverty school districts are poorly funded. To make matters worse, these students are taught disproportionately by inexperienced and poorly prepared teachers. These students are not held to high expectations and are generally given assignments that represent lower standards than those given to other students (Haycock and Jerald, 2002).

Some states are doing a better job than others in closing the achievement gap. For instance, fourth grade mathematics scores on the NAEP showed that in the country as a whole, African American students had about a 13-point growth during the 1990s. However, in three states – North Carolina, Texas, and Indiana – African American fourth graders gained almost twice as much (Haycock and Jerald, 2002).

Significant differences also occurred in the rates at which different groups of students completed high school and postsecondary education experiences. The following table (Table 1) shows these discrepancies (US Census Bureau, 1998).

Table 1

Highest Educational Attainment for Every 100 Kindergartners

Ages 15-29	African Americans	Asians	Latinos	Whites
Graduate from high school	88	90	63	88
Complete at least some college	50	74	33	59
Obtain at least a bachelor's degree	16	51	10	28

Clearly, as the table above shows, an achievement gap exists between American and Asian students. Part of the reason for this gap is that American students, their parents, and their teachers have maintained a set of low standards for performance as compared to their Asian counterparts (Stevenson & Stigler, 1992).

When adults were asked about the achievement gap, comments generally addressed issues such as economic status of the family, parental attitudes, and even whether or not students have had breakfast on any given morning. Students, however, expressed different views. Often they stated that teachers don't know enough about the subject they are teaching. They also talked about counselors who underestimate their potential and place them in lower-level courses along with a curriculum and a set of expectations that "literally bore the students right out the school door" (Haycock, 2001, p.8).

Research has suggested that the factors that matter most for student achievement on standardized tests are teacher instructional actions, teacher expectations for students, students' total weekly out-of-school time in high yield activities, activity quality, parental standards, beliefs and expectations, and teacher-parent communication. Once school process factors and family process factors were accounted for, student ethnicity and socioeconomic status were nearly eliminated as impacts on student achievement. Rather, higher scores were most consistently associated with behaviors of students, teachers, and parents (Clark, 2002).

High-achieving students spend more time engaged in academic lessons than their lower-achieving counterparts and they spend more time in 'high-yield' activities out of school such as leisure reading, seeking tutoring, participating in community and school clubs and programs, being involved in hobbies, and playing organized sports (Clark, 2002).

In schools that have closed or eliminated the achievement gap, teachers have a commitment to teaching students to read. A portion of the rationale is that students cannot pass standardized achievement tests they cannot read (Bell, 2003).

In a report by the Michigan Association of School Boards in 2001, key facts about the Achievement Gap were outlined (Braverman, 2001):

- A wide racial/ethnic gap exists in achievement test scores. African American and Hispanic students score significantly lower, on average, than White and Asian students.
- The achievement gap is present before children start school.
- It is wrong to assert that the quality of public schools is declining because of the achievement gap. Over the past 25 or 30 years, every sub-group of students, including Black and Hispanic, has improved its average achievement.
- When achievement rises for all subgroups, African American and Hispanic students must improve at a faster rate than others for the gap to close.
- The achievement gap is not due to differences in innate ability, nor is it simply the result of biased test questions.
- Racial-ethnic differences in family income contribute to the achievement gap but do not entirely explain it.
- There is no simple explanation for the achievement gap. A variety of school, community, and home factors seem to underlie or contribute to the gap.

Research has identified several strategies that are effective in raising student achievement. They include (Braverman, 2001):

- Investing in teacher professional development
- Lowering class size in high-minority schools
- Increasing the participation of minority students in challenging academic courses and rigorous instruction
- Implementing comprehensive, research-based models for school improvement.

- Expanding access to high-quality preschool programs
- Providing extended learning time and more intensive programs for students who are having difficulty
- Strengthening parent and community support for learning

Strategies have also been identified that help close the achievement gap (Braverman, 2001):

- Changing curriculum and instruction
- Improvements in teacher preparation and professional development
- High standards and accountability for subgroup performance
- Equitable distribution of resources
- Sustained class size reductions in high-minority schools
- Comprehensive school reform
- Extended after-school and summer learning opportunities
- Targeted research on promising strategies and unanswered questions
- Expanded access to high-quality preschool programs

In order to close the achievement gap, school districts must first acknowledge that the problem exists. Not all districts break down student performance data to show how various racial and ethnic groups perform (Rothman, 2002). Accountability with the *No Child Left Behind Act of 2001* will cause districts to reexamine how data are reported.

Best Practice

Educators have spent countless resources and untold hours searching for best practices in the field. Schlechty (2001) reported:

> For schoolwork to be judged quality work, the tasks to be accomplished must be designed and presented in such a way as to be authentically engaging. More than that, quality

schoolwork results in students' persisting with the tasks assigned until their work meets the desired standard (pp. 70-71).

As teachers look at designing quality work, they must examine best practices in mathematics instruction. According to the National Council of Teachers of Mathematics (NCTM), best practices are evident in activities that have students actively involved in doing mathematics so they can build their understanding of mathematical ideas, see the power and usefulness of mathematics in their daily lives, and feel confident in their own capabilities as problem-solvers (Principles and Standards for School Mathematics, 2000). Characteristics of best practices embodied in the NCTM reports include:

- The goal of teaching mathematics is to help all students develop mathematical power.
- Teaching for mathematical power requires providing experiences that stimulate students' curiosity and build confidence in investigating, problem solving, and communication.
- How well students come to understand mathematical ideas is far more important than how many skills they acquire.
- Mathematics is not a set of isolated topics, bur rather an integrated whole.
- Problem solving is the focus of a curriculum that fosters the development of mathematical power.
- Students need many opportunities to use language to communicate mathematical ideas.
- Reasoning is fundamental to knowing and doing mathematics.
- Concepts of numbers, operations, and computation should be broadly defined, conceived, and applied.
- The concepts of geometry and measurement are best learned through experiences that involved experimentation and the discovery of relationships with concrete materials.

- The understanding of statistics, data, chance, and probability comes from real-world applications.

To move toward these best practice descriptors in mathematics teaching, some change will be required in the way math classes have been taught in the past. Changes in practices, minor or substantial, require good implementation and staff development. Consistent attention over years (not months) to developing teachers' capabilities for teaching mathematics in different and or better ways is critical (Zemelman, Daniels, & Hyde, 1998).

Many adults believe they have a clear sense of what mathematics is and why they despise it (Zemelman, Daniels, & Hyde. 1998). Their personal experiences over the years in school have solidified negative attitudes toward mathematics by struggling with textbooks, memorizing math facts, computing page after page of algorithms, going to the chalkboard to work an answer in front of their peers, and developing the dreaded carefully constructed proof.

Myths abound about the teaching and learning of mathematics (Foreman, 1995). For example:

- Sharing ideas, thoughts, and feelings about mathematics is not appropriate in a math class.
- There is only one right way to do math.
- The teacher's role is to give answers.
- Manipulatives and models are only used in the lower grades.
- Mathematics is arithmetic.
- Some people can't do math.
- Working together on math problems is cheating.

These ideas are fundamentally wrong. Teaching practices, textbooks, or curricula that embody these myths serve to foster the continuation of maintaining this mythology. Perhaps the saddest outcome of this perpetuation is that there are children who come to school who believe they are incapable of doing math, at least not in an acceptable fashion (Zemelman, Daniels, & Hyde, 1998). The "drill and kill" mentality of some educators may have been acceptable for the shopkeepers of the nineteenth century, but its effects are two-fold. Anxiety and a loathing of mathematics are drilled into some children, and, of equal importance, our students today need much more than learning basic facts and algorithms. The long-term effects are enormous. When we eliminate the enjoyment and understanding of mathematics in younger children, they begin to avoid elective math courses at the high school level. When students are given the opportunity to continue in non-required math courses, each year only about half continue. Only a very few elect to major in mathematics in college (Zemelman, Daniels, & Hyde, 1998).

A videotape of the teaching style in a "typical" U. S. eighth-grade math class is included in the materials from the TIMSS report. This videotape shows a teaching style that displayed a "numbingly predictable" approach. (Before It's Too Late, 2000, p. 20). First, the teacher conducted a review of previous material and/or homework. Next, the teacher illustrated a problem while the students watch. Then there was drill on low-level procedure that imitated those demonstrated by the teacher. Then there was supervised seatwork done by the students, often in isolation. Seatwork was checked and homework was assigned. In not one of the 81 videotaped U.S. classes did the students construct a mathematical proof (Before It's Too Late, 2000).

Also included in the TIMSS report materials is a videotape of students in a Japanese classroom. Closely supervised, collaborative work among students was the norm. Japanese students were often presented with a mathematics problem that incorporated principles the students had not yet learned. Then they worked either alone or in small groups to develop a solution. After an appropriate amount of time, students were asked to present their solutions to the class. The whole class then worked through problems and solutions, uncovering the mathematical concepts embedded in the problems. This discovery method was quite different from the typical U.S. approach of lecture alone (Before It's Too Late, 2000).

In Asia, national curriculums defined what is expected of children at each grade level, and textbooks conformed to these standards (Stevenson, 1993). The US does not have a curriculum that is developed and mandated on a national level. States, local BOEs and individual schools have established their own curriculums. They can decide how to organize subjects, the rate at which material is presented, and how the material is assessed. Often, the innovative idea is embraced and fairly young curriculums are replaced with even newer ones. The *No Child Left Behind Act of 2001* set rigorous expectations and states are scrambling to meet them. Some national organizations have set some guidelines that have been met with approval. The guidelines of the National Council of Teachers of Mathematics standards have been praised as a model for other organizations.

Research and experience show that what goes on in schools matters greatly. Historically, we have neither agreed upon what students in the United States should learn at each grade level nor what kind of work is good enough. These decisions have been left to individual school districts and, in some cases, to individual schools and teachers. The result is a system that does not set uniformly high standards. High poverty schools are sometimes hit hardest in terms of how little is expected of students in terms of learning (Haycock, 2001). Setting high standards is a key component in closing the achievement gap. Kentucky was the first state to initiate standards-based reform in education. Ten years ago, Kentucky passed legislation that set high learning goals for students and clearly stated the expectation that all children, regardless of socioeconomic status, would meet these goals. Kentucky has not fully realized these goals, but they are making progress. For example, in math, 8 of the top 20 performing schools in the state are high-poverty schools (Haycock, 2001).

Students must have a challenging curriculum. The National Council of Teachers of Mathematics published its original set of curriculum and evaluation standards in 1989. These standards were revised in 2000 and are supported in virtually every state. Although the NCTM standards are not a formal curriculum, they serve as a framework around which state curricula are usually structured.

We know that the more rigorous the curriculum, the higher students perform on assessments. For example, in mathematics, students who completed the full college-preparatory sequence of mathematics courses performed much higher on the National Assessment of Educational Progress (NAEP) than those students who completed only one or two courses. The reverse is also true. The more vocational or technical education courses students took, the lower their performance on the NAEP. These patterns show that the quality and intensity of high school coursework are the most important determinants of success in college-level courses – more important that class rank or score on college admissions tests (Adelman, 1988).

There is evidence that almost all students can achieve at high levels if they are taught at high levels. We also know that some students require more time and opportunity than others. For example, it does no good to place a student in a high-level math course if he or she cannot read the textbook (Haycock, 2001). When students are behind in foundational skills in mathematics, we need to double or triple the amount and quality of instruction they get.

Key here is the quality of instruction. Improvement can only occur when the thing to be improved is brought under control. Teachers are right when they say there are many things over which they have no control, leading to frustration within the ranks of teachers. It is true that teachers and schools have no control over many factors in a student's education, such as poverty, ethnicity, parental involvement, nutrition, and even the district calendar. However, there are some things teachers can control. We can control the climate within the classroom. We can control the focus of instruction. And, arguably the most important, we can control the quality of the work we give students to do. Quality work leads to student engagement, which should be a central concern for the teacher. When students are not authentically engaged in quality work, and may be only ritually engaged or simply compliant, then learning and conceptual understanding cannot occur at maximum levels (Schlechty, 2002). Conceptual understanding, mathematics anxiety and memorization are connected. If students have a deep conceptual understanding of mathematics, they will need to rely less on arbitrary, memorized facts and rules and will exhibit less mathematics anxiety (Alsup 2003).

The TIMSS study showed that US students fell in the bottom quartile of student achievement because they were very good at the basics. Schools that focus on the basics for at-risk students perpetuate this level of achievement because they never get past the basics. Higher-order thinking skills should be taught to all students. Strategies such as asking probing, open-ended questions about the mathematics and giving students time to process and share information are key in this effort. Students who are at-risk are sometimes classified as such because of absence in class. They often do not 'get it' the first time the material is taught. Therefore teachers must routinely reteach material in a variety of ways. For example, a short daily review and check for understanding are critical. Frequent assessments are imperative for the teacher to understand where students are in their learning (Bell, 2003). At-risk students must participate in class. Teachers should not call on only those students who have raised their hands to answer questions or participate.

- High quality teaching can be learned and refined over time.
- Training, mentoring, collaboration with peers and practice are essential.
- Teachers must have a deep knowledge of their subject matter.
- An inquiry-based approach is not merely ‘giving instruction.’
- High expectations are in place for students to learn.
- Students are encouraged to try new possibilities or approaches to solve a problem.
- Students should be expected to defend and justify their answers and solutions.
- Teachers must allow for individual learning styles and abilities.
- A thorough alignment of curriculum, assessment, and high standards must be in place.
- Professional development, continuing education, effective use of technology, and recognition and rewards must be in place for teachers (Before It’s Too Late, 2000).

Teachers must have strong backgrounds in the subjects they teach if we are to hold students to high standards and make progress toward closing the achievement gap. Nationally, an alarming 40% of teachers in high schools with greater than 49% free and reduced lunch do not have a major or minor in mathematics. Even in schools with less than 20% free and reduced lunch, 25% of the teachers are considered underqualified by the same standard (Haycock, 2001).

In Texas, some school districts reversed the pattern of placing teachers. Districts with initially high-performing first graders hired from the bottom of the teacher pool, while districts with initially low-performing first graders hired from the top of the teacher pool. By the time these first graders reached high school, these districts had exchanged places in student achievement (Ferguson, 1998). Additionally, eight years ago in El Paso, local education leaders set very high standards for what their students should know and be able to do. Moreover, at the University of Texas, El Paso, the faculty revamped how teachers were prepared. For example, new elementary teachers took more than twice as many mathematics courses as their predecessors (Haycock, 2001).

Haycock and Jerald suggested that principals become more proactive in their approach to improving student achievement. Principals should take the initiative in four critical areas:

- Assume the responsibility for closing the achievement gap within their own buildings. They should back up their rhetoric by sharing and disaggregating data, especially about opportunities afforded to poor and minority students. Are they getting their fair share of qualified teachers and are they subjected to the same high expectations of their counterparts?
- Standards should be used to reshape and define curriculum and instruction. Research from the Education Trust reveals the low number and quality assignments high-poverty students receive. Clear standards must be in place that reveal what students should be expected to learn at each grade level.
- Extra instruction should be provided for students who need it. Some students need more time and opportunity for learning to occur. This often requires creativity on the part of administrators. Before and after school programs as well as additional time created within the school day are ways to increase instructional time.
- Assign the strongest teachers to the students who need them most. Research supports the fact that teachers are the most important part of the learning equation. Poor and minority

students are twice as likely to be assigned to classrooms with inexperienced or otherwise ineffective teachers (Haycock & Jerald, 2002).

Manipulatives

Traditionally, teachers have relied on workbooks, drills, and memorization to present mathematics concepts. However, the use of these approaches "has proven to be ineffective and outdated" (Cain-Caston, 1996, p. 271).

The use of manipulatives strengthens pedagogical ideals, reinforcing the notion that worksheets should not be the beginning or the end of any student's mathematical experience (Moch, 2001). According to Fuson (1992) and Carpenter and Moser (1983), it is important to have manipulatives available to children to support their thinking. Students have been "using objects to model the situations long before they have memorized facts or learned to use written symbols" (Carroll & Porter, 1997, p. 373).

Students demonstrate sensory-concrete knowledge when they use sensory material to make sense of an idea. For example, at early stages, children cannot count, add, or subtract meaningfully unless they have actual objects to touch. "Concrete" cannot be equated simply with physical manipulatives. Computers might supply representations that are just as personally meaningful to students as are real objects; that is they might help develop additional knowledge (Clements & McMillen 1996).

Students who use manipulatives in their mathematics classes usually outperform those who do not (Driscoll, 1983; Sowell, 1989; Suydam, 1986). This benefit holds across grade level, ability level, and topic, given that using a manipulative makes sense for the topic. Manipulative use also increases scores on retention and problem-solving tests. When students are instructed with concrete materials by teachers knowledgeable about their use, their attitudes toward mathematics are improved (Sowell, 1989).

In certain topics, such as early number concepts, geometry, measurement, and fractions, the proper use of manipulatives is especially crucial. However, manipulatives alone are not sufficient – they must be used to actively engage children's thinking with teacher guidance (Clements & McMillen 1996).

Manipulatives can play a role in students' construction of meaningful ideas. They should be used before formal instruction, such as teaching algorithms. However, teachers and students should avoid using manipulatives as an end – without careful thought – rather than as a means to that end (Clements & McMillen 1996).

Opening Eyes to Mathematics is a program of instruction that implements a constructive, active, problem-oriented learning process for students. Targeted at the third and fourth grade levels, the program embraces the philosophy that children learn best when they construct their own understanding and draws upon children's ability to think visually. Students work with manipulatives, diagrams and visual models to learn mathematical concepts and ideas (Head, Pollett, & Arcidiacono, 1995). Although not a formal adopted curriculum that uses traditional textbooks, the use of manipulatives integrated in the Opening Eyes to Mathematics program and others is considered an integral part of instruction.

Using manipulatives well takes time and practice. Using them strictly because they are the latest fad or because of some administrative mandate, without teachers investing their time or interest, results in a less than desirable outcome for students, teachers, and administrators. "Using manipulative materials well takes reflective practice and blind compliance to the uncritical use of manipulatives is not the answer" (Karp and Voltz, 2000, p. 212). Simply using manipulatives does not guarantee a good mathematics lesson (Stein & Bovalino, 2001).

Student reflection on activities using manipulatives enhances mathematical learning and reduces mathematics anxiety (Cain-Caston, 1996). Using manipulatives for teaching mathematical concepts in the classroom may not work initially for everyone or for everything. Teachers must gain proficiency in learning to use manipulatives appropriately.

Simply using manipulatives for manipulatives' sake can be counter-productive. To gain the proficiency needed and to increase the positive effect the use of manipulatives can have on student learning, Clements and McMillen offer some suggestions. Increase the students' use of manipulatives. Most students do not use manipulatives as often as needed. Thoughtful use can enhance almost every topic. Also, short sessions do not significantly enhance learning. Students must learn to use manipulatives as tools for thinking about mathematics.

Recognize that students may differ in their need for manipulatives. Teachers should be cautious about requiring all students to use the same manipulative. Many students might benefit more if allowed to choose their own manipulatives. Encourage students to use manipulatives to solve a variety of problems and then to reflect on and justify their solutions. Such varied experience and justification help students build and maintain understanding. Ask students to explain what each step in their solution means and to analyze any error that occurred as they use manipulatives – some of which may have resulted from using the manipulative (Clements & McMillen, 1996).

Teachers must become experienced with manipulatives in order to be effective. Attitudes toward mathematics, as well as concepts, are improved when students have instruction with manipulatives, but only if their teachers are knowledgeable about their use (Sowell, 1989).

When teachers close their eyes and picture children doing mathematics, manipulatives should still be in the picture, but the mental image should include a new perspective on how to use them (Clements & McMillen, 1996). Teachers must understand that some manipulatives have multiple uses in terms of instruction and can be used to teach more than one concept.

More than one manipulative should be used to teach concepts. Different children may find different models meaningful. Discussing different models may help students understand abstract mathematical ideas. Brief and trivial use will not help; each manipulative should become a tool for thinking. Different manipulatives allow, and even encourage, students to choose their own representations (Baroody, 1990).

Some educational views encourage teaching mathematics more in depth and with less coverage (Bruner, 1995). This is consistent with the "mile-wide-inch-deep" dilemma faced by educators, but is difficult under current curriculum reforms, especially given the standardized testing pressures felt by many classroom educators.

These testing pressures and the perceived need to cover a large amount of curriculum quickly inhibit some novice and veteran teachers from using manipulatives. Many instructors believe using manipulatives to teach mathematical concepts takes up too much classroom time; some even argue that the benefits to students are minimal (Smalley & Moch, 1999). Some teachers use manipulatives as a type of reward system for good behavior rather than as an important tool.

Some universities incorporate the use of manipulatives in their preparation of elementary teachers. For example, the University of Central Florida program trains preservice teachers to use manipulatives in their future classrooms. The use of manipulatives is considered a best-practice pedagogical technique (Moch, 2001). During their junior and senior internship field experiences, however, these students frequently reported that manipulatives were not often used for mathematical instruction or, in too many instances, were banned from use in supervising teachers' classrooms altogether. Though research and theory support the use and benefits of using manipulatives in the classroom, actual practice does not seem to follow this pedagogical model (Hatfield, 1994).

Although many preservice teachers are convinced of the usefulness and benefits of using manipulatives to teach young children mathematics, but for various reasons they choose not to employ maniulatives routinely in their personal practice following graduation. When asked why, answers range from the lack of availability of kits, to lack of administrative support and being overwhelmed with other classroom responsibilities.,. Novice teachers, in their first year or so of teaching, are in survival mode and probably have not yet had time or sufficient practice to use manipulatives as effectively as they would like in their curriculum (Moch, 2001).

Professional Development

The magnitude of teacher effects on student achievement has gained importance in light of previously held views that home and social background effects were more significant contributors to achievement than what happens at school. Research indicates that teachers are the most important factors affecting student learning. Some researchers suggest that more can be done to improve education by improving the effectiveness of teachers than by any other single factor (Wright, Horn, & Sanders, 1997). "Differences in the effectiveness of individual classroom teachers are the single largest factor affecting the academic growth of students (Sanders, 1998, p. 27).

As the most important factor in the mathematics learning of students, it is alarming to find that more than one in four high school math teachers lack even a minor in mathematics.

About 27% of high school students are taught by out-of-field teachers. These percentages are even greater in high poverty areas. The basic teaching style in many math classes remains essentially what it was two generations ago. By contrast, teaching innovation and higher student performance are well documented in other countries, where students' improvements are anchored to an insistence on strong professional development for teachers (Before It's Too Late, 2000).

Monahan (1996) states that many teachers and some administrators view professional development as special events that are restricted to 3 or 4 days during the school year that are set aside for those activities. Teachers rarely have input into the content or planning of the activities and the content may or may not be relevant to their classroom situations. The requirement of a certain number of hours of professional development in order to maintain professional certification sometimes contributes to a narrow view of professional development (Monahan, 1996). Although there are some instances in which allocating certain days to these activities is appropriate, it can reinforce the notion that professional development is a separate activity from their ongoing tasks and responsibilities (Guskey, 2000).

Glickman, et al (1995) said that teacher staff development is rarely individualized for teachers. Schools tend to continue to provide the same kinds of staff development rather than focusing on varying teachers' needs. Because teachers learn best that which they perceive a need to know, the internalization and application of new knowledge is not as effective when delivered with a one-size-fits-all approach.

For many years, according to Guskey (2000), researchers have been largely unsuccessful in determining the true impact of professional development for teachers on the learning of their students. Staff development sessions are a core component of many school systems and are often well attended. Although valued, we still don't know a great deal about what difference it makes. There are many reasons this research may be inconclusive. One is confusion about the criteria. Effectiveness is a topic upon which researchers and evaluators have not always agreed. Some researchers select participant reaction as determined by evaluations as criteria. Other studies are based on changes in attitudes of participants or commitment to make changes. Still others look at the level of implementation of the new learning. Without common criteria, accurate comparison across studies is difficult (Guskey, 2000).

A second reason for this limited progress in search of effective elements in professional development is that consistencies across studies become viewed as the primary effects and are sometimes the only focus in evaluation. The peripheral information contained in the studies may offer as much insight as the major consistencies (Guskey, 2000). For example, the effects of professional development on student learning vary widely as determined by content of the session, the structure and format of the session, and the context in which implementation occurs (National Staff Development Council 1994, 1995a, 1995b). An excellent choice of content may be poorly presented or teachers may not have had the administrative support needed to appropriately implement what they learned. Conversely, a professional development session can be powerfully presented and well-supported, but appropriate and reliable research may not support the endeavor (Guskey, 2000). Focus on the primary, or general, effects may obscure the critical questions about the conditions under which professional development is likely to yield positive effects.

A third reason of unsuccessful efforts to identify elements of effective professional development is that the focus becomes on quantity versus quality. Creating indicators of a quality professional development is time consuming and difficult. For example, collaboration among peers is typically a desired outcome of professional development. But then the question becomes one related to how collaboration is measured and with what frequency. Moreover, all collaboration may not be positive or productive (Guskey, 2000).

An alternative approach with which to research effective professional development is to look for positive results in student learning and identify efforts that have produced evidence of success. Looking for programs that have led to reliable measures of student learning can yield valuable information in terms of the content, process, and context of delivery of the professional development involved in implementing a program or idea (Guskey, 2000).

Examples of two states that have produced impressive results by focusing on better teaching are Texas and North Carolina. In Texas, a study of grades 1-11 found that teachers' subject-matter expertise accounted for 40% of the difference on achievement tests. Disparities between white and minority students were almost entirely accounted for by the qualifications of their teachers. North Carolina students entered the 1990s near the bottom of the NAEP rankings in mathematics. After the state boosted minimum salaries, used scholarship programs to recruit more able students to teaching, invested in better teacher education curricula, created professional development academies, instituted mentoring programs for entering teachers, and created incentives for teachers to be certified by the National Board of Professional Teaching Standards, North Carolina students now score well above the NAEP averages (Quality Counts 2000: Who Should Teach? 2000).

When professional development is designed, the characteristics of the adult learner should be kept in mind. As Arnau (2001) noted, "veteran teachers learn differently from children because, as adults, they move through a continuum of developmental stages based on their personalized needs" (p. 7).

Malcolm Knowles (1980) defined andragogy, a theory widely used in adult learning literature, as "the art and science of helping adults learn" (p. 38). The term is based on the psychological definition of adult, which states that people become adults psychologically when they arrive at a self-concept of being responsible for their own lives, of being self-directing.

Andragogy is based on six fundamental assumptions about the unique characteristics of adult learners:

- The learner's self-concept. Once adults have arrived at the stage where they take responsibility for their own lives, they develop a deep psychological need to be seen and treated by others as being capable of self-direction.
- The role of the learner's experience. Adults enter a learning experience with both a greater volume and wider diversity of experience than children.
- Readiness to learn. Adults are ready to learn what they need to know and be able to do in order to cope effectively with their real-life contexts.
- Orientation to learning. Adults are problem-centered, or life-centered, in their learning orientation. They are motivated to learn to the extent that learning will help them perform tasks or deal with real-life problems.
- Need to know. Adults need to know why they should learn something before devoting the energy to it.
- Motivation. The best motivators are internal, such as self-esteem, quality of life, or increased job satisfaction.

The implications of Knowles' research are to provide adults with opportunities to set their own goals, establish a need to know and readiness to learn, provide opportunities to link new information with prior knowledge, and provide adults with individual responsibility for their learning.

The most effective professional development has not been clearly defined and best practices in the area have not been consistently and uniformly interpreted in terms of nuts and bolts. However, there seem to be some major tenets in practices and strategies that are common to successful efforts. These principles are clear, consistent, and appear to be integral to the process of improving results in student learning. First, there must be a clear focus on learning and learners. This can take a variety of forms, but the emphasis must be on high learning standards for all students as the primary goal (Guskey, 2000).

Second, there must be an emphasis on individual and organizational change. Administrators and teachers must embrace a commitment to improve and this is often facilitated by systemic change. Common planning time for teachers is a first step in collaboration. Principals may arrange for coverage while a teacher observes a colleague. Practices that foster cooperation and professional respect must be in place (Fullan, Bennett, & Rolheiser-Bennett, 1989).

Third, small changes must be guided by a much larger vision. Small, incremental steps foster sustained effort. The larger vision enables all involved to view the smaller steps as a unified effort toward the single goal. Drucker has noted that noticeable and sustained effort cannot be so massive as to require the individual to adopt strategies for coping that actually distort the change or alter the focus (Drucker, 1985).

Finally, professional development must be ongoing and procedurally imbedded. It is not separate from a teacher's daily routine and responsibilities. It must be interwoven and imbedded throughout the educator's life. It should become something teachers naturally do within the context of developing and evaluating curriculum content, delivering their lessons, and developing assessments and interpreting results. Regardless of when it is offered, professional development should be an ongoing process. Workshops and presentations must be accompanied by appropriate follow-up activities (Guskey, 2000).

Preservice Training

Preservice elementary teachers, as students in traditionally taught high school and university mathematics courses, often have experienced teacher-centered mathematics instruction that focuses on rules, formulas, and answers. Conversely, if they experience a mathematics course that is student-centered, with an emphasis on active learning, communication and reasoning, they most likely will be able to teach children mathematics effectively at the elementary level in a manner consistent with the vision of the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (NCTM, 2000).

Research suggests that preservice elementary teachers have not received mathematics instruction that is consistent with the vision of the NCTM Standards. Rather, their instruction has been based on procedures and lectures (Battista, 1999; Manouchehri, 1997; O'Brien, 1999). In mathematics classrooms of many colleges and universities, instructional approaches such as multiple representations, open explorations, and meaningful investigations of ideas have not replaced the lecture (Manouchehri, 1997). Ball (1990, 1996) concluded that preservice elementary teachers have a weak, fragmented knowledge of mathematics, mostly acquired facts and memorized rules; she further asserted that they have rarely seen or experienced a kind of teaching that, focusing on conceptual understanding, engages students in complex reasoning in authentic contexts. In a meta-analysis of 151 research studies Hembree (1990) discovered that preservice elementary teachers have the highest level of mathematics anxiety of any major on university campuses. Emenaker (1996) found that preservice elementary teachers, with improvement in conceptual understanding, relied less on the memorization of facts, algorithms, and formulas. Conceptual understanding, mathematics anxiety and memorization are connected. If students have a deep conceptual understanding of mathematics, they will need to rely less on arbitrary, memorized facts and rules and will exhibit less mathematics anxiety (Alsup, 2003).

Mathematics anxiety is prevalent among the preservice teacher population (Hembree, 1990). This is cause for concern, considering that teachers who possess higher levels of mathematics anxiety may unintentionally pass on these negative feelings to their students (Wood, 1998). Some researchers have proposed that mathematics anxiety may stem from teaching methods that are conventional and rule bound (Tobias, 1993). This rule-based methodology is most often employed by elementary teachers who themselves have high levels of mathematics anxiety and negative attitudes toward mathematics (Bush 1989; Karp, 1991). Moreover, mathematics instructors who teach primarily through lecture and rote memorization of algorithms often neglect to meet the learning styles of all students and, therefore, may unintentionally perpetuate mathematics anxiety (Hodges, 1983; Zaslavsky, 1994).

"How People Learn: Brain, Mind, Experience and School" is a National Research Council study that summarized research on learning (Bransford, Brown, & Cocking, 1999). Some of their key findings were relevant to undergraduate mathematics.

Relative to learners and their learning:

- Skills and knowledge must be extended beyond the narrow contexts in which they are first learned.
- Knowledge learned at the level of rote memory rarely transfers.

- Learners are helped in their independent learning attempts if they have conceptual knowledge.
- Learners are most successful if they are mindful of themselves as learners and thinkers.

Relative to expert vs. novice performance at the college level:

- Experts notice patterns that are not noticed by novices.
- Experts have organized content knowledge that reflects a deep understanding of the subject matter.
- Experts' knowledge cannot be reduced to sets of isolated facts. Instead, their learning reflects application of facts within contexts.
- Experts have varying levels of flexibility in their approaches to new situations.
- Though experts know their disciplines thoroughly, this does not guarantee that they are able to instruct others effectively.

Relative to effective teaching:

- Effective teachers need pedagogical content knowledge about how to teach mathematics, which is different from knowledge of general teaching methods.
- Expert teachers know the structure of their disciplines and incorporate appropriate assignments, assessments, and questioning techniques within their classrooms.

Teacher Attitudes, Perceptions and Effectiveness

It is not enough to think that an advanced degree in mathematics is evidence of adequate preparation to teach effectively. Though experts may know their disciplines thoroughly, this does not guarantee that they are able to instruct others effectively. Effective teachers need pedagogical content knowledge about how to teach mathematics, which is different from knowledge of general teaching methods (Bransford, Brown, & Cocking, 1999).

Debates have long been in place about which factors most significantly affect student achievement. Essentially the debate centers between external factors (home and social background effects) and internal factors (classroom and school effects). Sanders claimed that differences in the effectiveness of individual classroom teachers are the single largest contextual factor affecting the academic growth of students (Sanders, 1998). The impact of decisions regarding instruction made by individual teachers is crucial. Robert Marzano (2003) states, "…all researchers agree that the impact of decisions made by individual teachers is far greater than the impact of decisions made at the school level" (p, 71). While individual teachers are necessarily influenced by decisions made by the school, teacher-level factors are a powerful influence on student learning. These factors include, but are not limited to, instructional strategies, classroom management, and classroom curriculum design (Marzano, p. 71).

In reporting on an analysis of achievement scores from five academic areas (mathematics, reading, language arts, social studies, and science) for approximately 60,000 students in grades 3 - 5, Wright, Horn & Sanders noted that the teacher is the most important factor affecting student learning. They suggested that improving teacher effectiveness can do more to improve education than any other single factor and that effective teachers appear to be effective with students of all achievement levels regardless of the levels of heterogeneity in their classes (Wright, Horn, & Sanders, 1997).

Haycock (1998) noted that the results of Sanders' research is most revealing in terms of comparing the achievement differences between students who spend a year with a highly effective teacher as opposed to a less effective teacher. On the average, the most effective teachers produced gains of about 53 percentage points in student achievement over one year, as compared to the least effective teachers, who produced achievement gains of about 14 percentage points over one year. Researchers estimate that student typically gain about 34 percentile points in achievement during one academic year (Glass, McGaw & Smith, 1981). For example, a student who scores at the 50th percentile in math in September will score at the 84th percentile on the same test given in May. Students in classes with more effective teachers will gain much more in achievement than is expected and students in classes with less effective teachers will gain much less in achievement than is expected. Moreover, the cumulative effect of poor teachers over a period of time can be devastating. According to the work of Sanders and his colleagues, the cumulative effects over three years between least effective and most effective teachers show an increase over time. The most effective teachers show an 83 percentile point gain and the least effective teachers show only a 29 percentile point gain in student achievement (Wright, Horn, & Sanders, 1997). These findings clearly show the importance of effective teachers not only as it relates to student achievement but also how it directly impacts the placement of students.

> Differences of this magnitude – 50 percentile points – are stunning. As all of us know only too well, they can represent the differences between a "remedial" label and placement in the "accelerated" or even "gifted" track. And the difference between entry into a selective college and a lifetime at McDonalds. (Haycock, 1998, p. 8)

Teachers generally believe that more time needs to be devoted to the teaching of mathematics. The four most frequent complaints from American teachers are that they are overworked, have too many responsibilities, lack knowledge in their field, and are not taught how to teach and manage students. American teachers spend most of their school day in the classroom teaching. High school teachers in Beijing typically teach only one subject two hours a day. The rest of their time is spent preparing for class, working with individual students, collaborating with colleagues, and correcting papers. Although they have a longer school day, Chinese and Japanese teachers enter the classroom with a level of preparation seldom seen by American teachers (Stevenson & Lee, 1990).

American teachers have generally been given additional responsibilities, especially at the high school level. For example, along with their teaching responsibilities, they are sometimes expected to counsel students, discipline students, and serve as coaches or advisors for everything from sports to debate clubs. The expectation of Asian teachers is that their primary function is to teach effectively and produce high levels of achievement. The peripheral duties fall upon parents or professionals outside the school setting.

In American schools of education, the typical pattern is for a prospective teacher to spend one semester as a student teacher. Sometimes, the aspiring teacher is assigned to an experienced teacher who is already overburdened with additional responsibilities. In Japan, the university classes are designed to give the student an education in their discipline. Learning to teach occurs in the actual classroom. Master teachers, relieved of other responsibilities for a year, can give full attention to working with new teachers (Stevenson, 1993).

In Fort Wayne, Indiana, the district conducted annual climate surveys to try to understand teacher and student attitudes. They found that African American students had more negative relationships with teachers than white students. They then instituted diversity training and changed the curriculum to include more contributions of people of color. According to the superintendent of Fort Wayne schools, the result was that the gap was closed between the way minority students and majority students saw their environment (Rothman, 2002).

Expectations of teachers toward their students have been shown to powerfully affect student performance (Rosenthal & Jacobson, 1968). Teachers in Department of Defense (DOD) schools hold extraordinarily high expectations of all students, including African American and

Hispanic students, and this is one reason attributed to their narrow achievement gaps. In a 1998 NAEP survey, 85 percent of black students and 93 percent of Hispanic students in DOD's domestic schools rated teacher expectations for their performance "very positive" as compared with 52 percent of black students and 53 percent of Hispanic students nationwide (Smrekar, Guthrie, Owens, & Sims, 2001).

Summary of the Literature

Recent reports of the performance of America's students in mathematics from both the Third International Mathematics and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP) echo a dismal message of lackluster performance (Before It's Too Late, 2000). NAEP data reveal lower levels of achievement in American students than the public expects and the TIMSS validates that finding by reporting that American students fall further and further behind international averages as they advance in school. In fourth grade mathematics, American students are generally at or slightly above international averages, although they are still significantly below the highest achieving students internationally. Eighth graders are below the international average and by high school, they are close to the bottom in terms of academic achievement.

American students were twelfth among 26 nations in fourth grade, twenty-eighth among 41 nations in eighth grade, and twelfth graders were tied for eighteenth among 20 nations. Students were not assessed from the same number of nations in all grades (Kearns & Harvey, 2000).

The educational community has paid a great deal of attention to the results of the TIMSS and NAEP. Widely reported in the media, these assessments on national and international levels have also caught the attention of legislators and politicians and have produced policy and legislation at state and national levels.

With the passage of the federal *No Child Left Behind Act of 2001*, Congress fundamentally redefined what it means to be a successful school. Schools will be judged not only on their average standardized test scores, but also on their ability to improve achievement among all groups of students. Hence, the term ‘achievement gap’ has taken on a much more significant meaning.

The achievement gap is difficult to close and represents a multi-dimensional problem. Many poor and minority children enter school already behind, given their lack of experiences that would be conducive to learning. Moreover, many high-poverty school districts are poorly funded. To make matters worse, these students are taught disproportionately by inexperienced and poorly prepared teachers. These students are not held to high expectations and are generally given assignments that represent lower standards than those given to other students (Haycock & Jerald, 2002).

Research has identified several strategies that are effective in raising student achievement. Among these strategies are the incorporation of identified best practices in education and investing in teacher professional development (Braverman, 2001).

Research has also suggested that the factors which matter most for student achievement on standardized tests are teacher instructional actions, teacher expectations for students, students’ total weekly out-of-school time in high yield activities, activity quality, parental standards, beliefs and expectations, and teacher-parent communication. Once school process factors and family process factors were accounted for, student ethnicity and socioeconomic status are nearly eliminated as impacts on student achievement. Rather, higher scores are most consistently associated with behaviors of students, teachers, and parents (Clark, 2002).

Sanders claimed that differences in the effectiveness of individual classroom teachers are the single largest contextual factor affecting the academic growth of students (Sanders, 1998). The impact of decisions regarding instruction made by individual teachers is far greater than the impact of decisions made at the school level Marzano, 2003). While individual teachers are necessarily influenced by decisions made by the school, teacher-level factors are a powerful influence on student learning. These factors include, but are not limited to, instructional strategies, classroom management, and classroom curriculum design.

Instructional strategies that have been proven to work include the use of manipulatives in the mathematics classroom. Students who use manipulatives in their mathematics classes usually outperform those who do not (Driscoll, 1983; Sowell, 1989; Suydam, 1986). This benefit holds across grade level, ability level, and topic, given that using a manipulative makes sense for the topic. Manipulative use also increases scores on retention and problem-solving tests. When students are instructed with concrete materials by teachers knowledgeable about their use, their attitudes toward mathematics are improved (Sowell, 1989).

Professional development is a key component in the development and growth of effective teachers. There seem to be some major tenets in practices and strategies that are common to successful efforts in professional development. These principles are clear, consistent, and appear to be integral to the process of improving results in student learning. First, there must be a clear focus on learning and learners. This can take a variety of forms, but the emphasis must be on high learning standards for all students as the primary goal (Guskey, 2000).

Second, there must be an emphasis on individual and organizational change. Administrators and teachers must embrace a commitment to improve and this is often facilitated by systemic change. Common planning time for teachers is a first step in collaboration. Principals may arrange for coverage while a teacher observes a colleague. Practices that foster cooperation and professional respect must be in place (Fullan, Bennett, & Rolheiser-Bennett, 1989).

Third, small changes must be guided by a much larger vision. Small, incremental steps foster sustained effort. The larger vision enables all involved to view the smaller steps as a unified effort toward the single goal. Drucker has noted that noticeable and sustained effort cannot be so massive as to require the individual to adopt strategies for coping that actually distort the change or alter the focus (Drucker, 1985).

Finally, professional development must be ongoing and procedurally imbedded. It is not separate from a teacher's daily routine and responsibilities. It must be interwoven and imbedded throughout the educator's life. It should become something teachers naturally do within the context of developing and evaluating curriculum content, delivering their lessons, and developing assessments and interpreting results (Guskey, 2000).

Much attention has been given to the continuing education of teachers who are already in the field. A major opportunity exists to better prepare our future teachers. Preservice elementary teachers, as students in traditionally taught high school and university mathematics courses, often have experienced teacher-centered mathematics instruction that focuses on rules, formulas, and answers. If they experience a mathematics course that is student-centered, with an emphasis on active learning, communication, and reasoning, they most likely will be able to teach children mathematics effectively at the elementary level in a manner consistent with the vision of the

National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (NCTM, 2000).

Math anxiety is prevalent among the preservice teacher population (Hembree, 1990). This is cause for concern, considering that teachers who possess higher levels of mathematics anxiety may unintentionally pass on these negative feelings to their students (Wood, 1998). Some researchers have proposed that mathematics anxiety may stem from teaching methods that are conventional and rule bound (Tobias, 1993). This rule-based methodology is most often employed by elementary teachers who themselves have high levels of mathematics anxiety and negative attitudes toward mathematics (Bush 1989; Karp, 1991). Moreover, mathematics instructors who teach primarily through lecture and rote memorization of algorithms often neglect to meet the learning styles of all students and, therefore, may unintentionally perpetuate mathematics anxiety (Hodges, 1983; Zaslavsky, 1994).

In reporting on an analysis of achievement scores from five academic areas (mathematics, reading, language arts, social studies, and science) for approximately 60,000 students in grades 3 - 5, Wright, Horn & Sanders suggested that the teacher is the most important factor affecting student learning and that improving the effectiveness of teachers can improve education more than any other single factor. Effective teachers appear to be effective with students of all achievement levels regardless of the levels of heterogeneity in their classes. Moreover the cumulative effects over three years between least effective versus most effective teachers showed an increase over time. (Wright, Horn, & Sanders, 1997).

CHAPTER 3

METHODOLOGY

Introduction

This chapter contains a discussion of the context of the study as well as the purpose, research design, population and sample for the research. A discussion of data sources, data collection and analysis procedures, the null hypothesis derived from the original research questions, and identification of the dependent and independent variables is also included.

The literature review discussed in Chapter 2 on achievement levels of American students as compared to international students, the achievement gap, identified best practices, the use of manipulatives, professional development, preservice training for teachers, and teacher attitudes, perceptions and effectiveness guided the formation of this study. These topics support efforts to answer important questions related to effective teachers.

Context of the Study

The study took place in a large, suburban school system in the southeast. During the 2002-2003 school year, 52 elementary, 16 middle, and 17 high schools served over 129,000 students. There were 22,000 employees in the district with a mathematics budget of approximately $7 million that included funds for textbooks, ancillary materials, manipulatives, calculators, and professional development for every school in the district.

The mission and vision statements embraced by the district define the major goal for the system to become a "system of world-class schools." High expectations are in place for students, teachers, local school administrators and district personnel in terms of teaching and learning, with an emphasis on student achievement.

The district is also acutely aware of the *No Child Left Behind Act of 2001* and is making proactive efforts to ensure that all schools make Adequate Yearly Progress as defined in NCLB. Newly adopted materials in mathematics coupled with heightened efforts to ensure student progress have facilitated extensive professional development in mathematics. The context in which this professional development is offered is largely summer professional development activities along with those activities offered on optional Staff Development Days that occur three times during the school year, typically in October, January, and March.

Professional development activities represent a sizeable portion of the budget for mathematics in the district. Teachers are required to attend implementation training for newly adopted materials and are also required to attend a minimum of 20 hours of professional development annually in order to successfully meet the expectations of the school district. Professional development activities are carefully and strategically designed to incorporate best practices and the use of technology and manipulatives into the daily teaching practices in classrooms. Several programs receive additional attention in terms of scheduling professional development opportunities. *Opening Eyes to Mathematics* is a program of instruction that embraces the philosophy that children learn best when they construct their own understanding. Students work with manipulatives and visual models to learn mathematical concepts and ideas. (Head, Pollett, & Arcidiacano, 1995). This program was specifically targeted in this study.

Purpose, Research Design, Population and Sample

The purpose of the study was to determine what relationship, if any, is present between average class mathematics achievement scores and one selected professional development experience of their teachers. The design of the study was a randomized descriptive statistics study that examined mathematics achievement data as reported by class averages between two groups of teachers. Specifically, the researcher examined reported class average mathematics achievement scores on the Georgia CRCT administered to all fourth graders during the spring of the 2002-2003 school year. These scores were examined for two groups of fourth-grade teachers. One group participated in the *Opening Eyes to Mathematics* professional learning and the other group did not participate in this training. A test of Homogeneity of Variances and a t-test were run to determine evidence of differences among the means of the two groups. Additionally, a graph was constructed to show the grand mean differences between the two groups of teachers.

Fourth grade regular classroom teachers in a large suburban school district in the southeast formed the population for this study. The randomized sample was formed from two groups of teachers. One group was composed of fourth grade teachers who have received training in the Opening Eyes to Mathematics program. Professional development rosters from the district Staff Development Office were examined to produce this list of teachers. Once identified as having received training, the teachers were assigned numbers and a randomized list of teachers was produced. This list of teachers was then examined and revised based on two criteria as verified through SASI:

- the teacher taught in the system during the 2002-2003 school year
- the teacher taught in a regular fourth grade classroom during the 2002-2003 school year

Once this identification was complete, teachers who did not meet these criteria were deleted from the randomized list, leaving 61 teachers remaining on the list. A group of 45 teachers was randomly selected from this list to form the group of OEM trained teachers.

The second group in the sample was developed from teachers who were not trained in the OEM staff development. The same process was followed for this group of teachers and a list of 45 numbers was produced. Once both lists were created, a total of 33 schools was represented with a combined total of 90 teachers. A checks and balances system was incorporated to ensure that a maximum of four teachers per school from both groups was included in the study. Test score data for the CRCT were collected for both groups of teachers using the system's SASI and StART data reporting tools.

Additional data were collected regarding the teachers in the sample. Table 2 shows the gender, years experience in the system in which the study was conducted and total years experience, National Board Certification status, and average years of teaching of both groups within the sample. Also shown is the Georgia certificate level held by individuals within the two groups of teachers. Level 4 certification is assigned to teachers with a Bachelor's degree, level 5 for a Master's degree, and level 6 for a Specialist's degree. None of the teachers in either group holds a Doctorate and two teachers in the non-OEM trained group hold National Board certification.

Table 2

Demographics of Teachers with and without Opening Eyes to Mathematics Training

Gender

	Male	Female	Total	% Male	% Female
Non OEM Trained	6	39	45	13 %	87%
OEM Trained	2	43	45	4%	96%

Years Experience

	Average Years in Study System	Total Average Years Teaching
Non OEM	7.1	13

Trained		
OEM Trained	8.7	13.8

Georgia Certification Level/National Board Certification

	Certificate Level 4	Certificate Level 5	Certificate Level 6	Certificate Level 7	National Board Certified	Average Certification Level
Non OEM Trained	18	23	4	0	2	4.69
OEM Trained	16	28	1	0	0	4.67

Certification Frequency and Percent

	Frequency	Percent
Bachelor's Degree (Level 4)	34	37.8
Master's Degree (Level 5)	51	56.7
Specialist's Degree (Level 6)	5	5.5
Total	90	100.0

Data Sources

Class average scores for the 2003 administration of the total mathematics portion of the fourth grade CRCT were collected for all 90 teachers. Class average test score data were collected for the sample population utilizing the School Administrative Student Information (SASI) and Student Assessment Reporting Tool (StART) data collection tools, both of which house data for the school system in the study. The StART tool was used to collect data on verification of teacher placement for the time period of the study. The SASI tool produced the data on the class average CRCT scores, based on a query written to extract that data.

Classes for these teachers were heterogeneously mixed and balanced according to ethnicity and socioeconomic status as determined by verification by the system's SASI and/or StART data.

In addition, all teachers were fourth grade teachers from schools with similar demographics and class size within the district and the number of students in each class did not exceed 30 students.

Data Collection and Analysis

Class average scores on the total mathematics portion of the fourth grade CRCT were collected for both groups of teachers within the sample. Scores for teachers who have received OEM training were compared to class average scores for teachers who have not received the training. Descriptive statistics showing the mean, standard deviation and standard error of the mean were run for the two groups. An Independent Samples Test includes the Levene Test of Homogeneity of Variances and a t-test to compare means.

The dependent variable in the study was mathematics achievement data as reported by total mathematics class average scores from the 2003 administration of the fourth grade Georgia CRCT. Table 7 (see Appendix) lists the mean scores of the CRCT for the two groups of teachers, those without OEM training and those who have received the training.

The independent variable in this study was participation in the Opening Eyes to Mathematics staff development training. One group of teachers in the sample participated in the training and the other group of teachers did not.

Null Hypothesis

The following null hypothesis was tested in this study:

Ho: There is no statistically significant difference in the class average scores of the total mathematics portion of the 2003 administration of the fourth grade CRCT for teachers in the same school system who have participated in Opening Eyes to Mathematics training as compared to teachers who have not participated in the same training, given similar classroom demographics.

A significance level of $\alpha = 0.05$ was incorporated in this study to assess the evidence against the null hypothesis. This significance level informed the researcher that if the P-value is 0.05 or less, then the null hypothesis would occur no more than 5% of the time.

CHAPTER FOUR

ANALYSIS OF DATA AND FINDINGS

Introduction

The findings of the study are reported and discussed in this chapter, along with analyses of the data. A review of the sample and population is provided as well.

Review of Sample and Population

The population for this study was all fourth grade regular classroom teachers in a large suburban southeastern school district. Two groups of teachers formed the randomized sample group. One group was fourth grade teachers who have received training in the *Opening Eyes to Mathematics* program as identified by professional development rosters from the district Staff Development Office. A randomized selection produced 45 teachers from this group. The second group of 45 teachers was randomly selected from the remaining, non OEM trained teachers in the district. The researcher verified through SASI that both groups of teachers in the study taught in a regular fourth grade classroom within the school district during the 2002-2003 school year. A total of 33 schools was represented, with no more than four teachers per school included in the study.

Variables

The dependent variable for this study was achievement data as reported by the class average scores on the total mathematics portion of the Georgia Criterion Referenced Competency Test given in the spring of the 2002-2003 school year.

The independent variable was whether or not teachers were trained in the *Opening Eyes to Mathematics* program as verified by staff development rosters.

Results

The findings in this section are the results of the statistical analysis of the data collected. Descriptive statistics are included, along with an Independent Samples Test that includes a Levene Test of Homogeneity of Variances, and a t-test. There is also a graph that shows results of the study.

To better understand the structure of the assessment that is referenced in the study, Table 3 shows the range of scores and their determination of level of student success. The scores for the total mathematics portion of the Georgia CRCT are reported numerically, but fall into three categories: does not meet, meets, and exceeds. These numerical values indicate the relative placement along the continuum of success for students.

Table 3

Levels of Achievement

CRCT	Does Not Meet	Meets	Exceeds
Mathematics	<300	300-349	350+

Table 4 reports descriptives from the CRCT data. The mean achievement score for the 45 teachers without training in *Opening Eyes to Mathematics*, indicated as 1 on the table, was 334.9. The mean adjusted achievement score for the 45 teachers with training in *Opening Eyes to Mathematics*, indicated as 2 on the table, was 341.1. Teachers with OEM training had a mean score 6.2 points higher than the group of teachers without training.

Table 4

Class Averages on 4th Grade CRCT Scores

	N	Mean	Std. Deviation	Std. Error Mean
Teachers Without OEM Training	45	334.8902	12.87645	1.91951
Teachers With OEM Training	45	341.1191	13.66826	2.03754

The Independent Samples Test includes a Levene Test of Homogeneity of Variances test (see Table 5). This test was performed to determine whether or not the samples in this study have equal variances, or homogeneity of variance. If the Levene statistic is significant at the 0.05 level or better, the researcher rejects the null hypothesis that the groups have equal variances. The results of the Levene test in Table 5 shows a significance level of .930, providing strong evidence that the researcher should accept the null hypothesis and conclude that the groups are homogeneous in variance. The Levene Test was used to verify the assumption of equality.

A t-test to determine equality of means is also included in Table 5. The t-test shows a P-value of .029, suggesting evidence against the null hypothesis of no difference among class average scores of the two groups of teachers. Relative to the variation among the class average scores within groups, the P-value suggests that something other than chance has influenced the statistics. The only known difference in the two groups is the presence or absence of training in *Opening Eyes to Mathematics*. This table also shows the difference of the means as 6.2289. The confidence interval for the difference in means indicated that the lower and upper bounds for the non-OEM trained teachers are -11.7919 and -.6659 respectively. For the OEM trained group of teachers, the lower bound is -11.7922 and the upper bound is -.6656. The 95% confidence interval selected by the researcher indicates that, given another sample selection from this population, the means for both groups of teachers would fall within the upper and lower bounds indicated in the table 95% of the time.

Table 5

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Class Avg Score on 4th grade CRCT math test	Equal variances assumed	.008	.930	-2.225	88	.029	-6.2289	2.7993	-11.7919	-.6659
	Equal variances not assumed			-2.225	87.688	.029	-6.2289	2.7993	-11.7922	-.6656

While the significance level of .029 in the t-test shows that the difference in the two groups is reliable, it says nothing about the magnitude of the difference. A calculation of the effect size can determine how much better or worse the experimental group did than the control group and can help clarify the practical interpretation of the results. The effect size is calculated by subtracting the mean of the control group from the mean of the experimental group and dividing by the standard deviation of the control group. The standard deviation of the control group is used because it is the basis of comparison and is not affected by the treatment. Thus, the following equation can be solved for the effect size:

$$\frac{341.1191 - 334.8902}{12.87645} = .48374$$

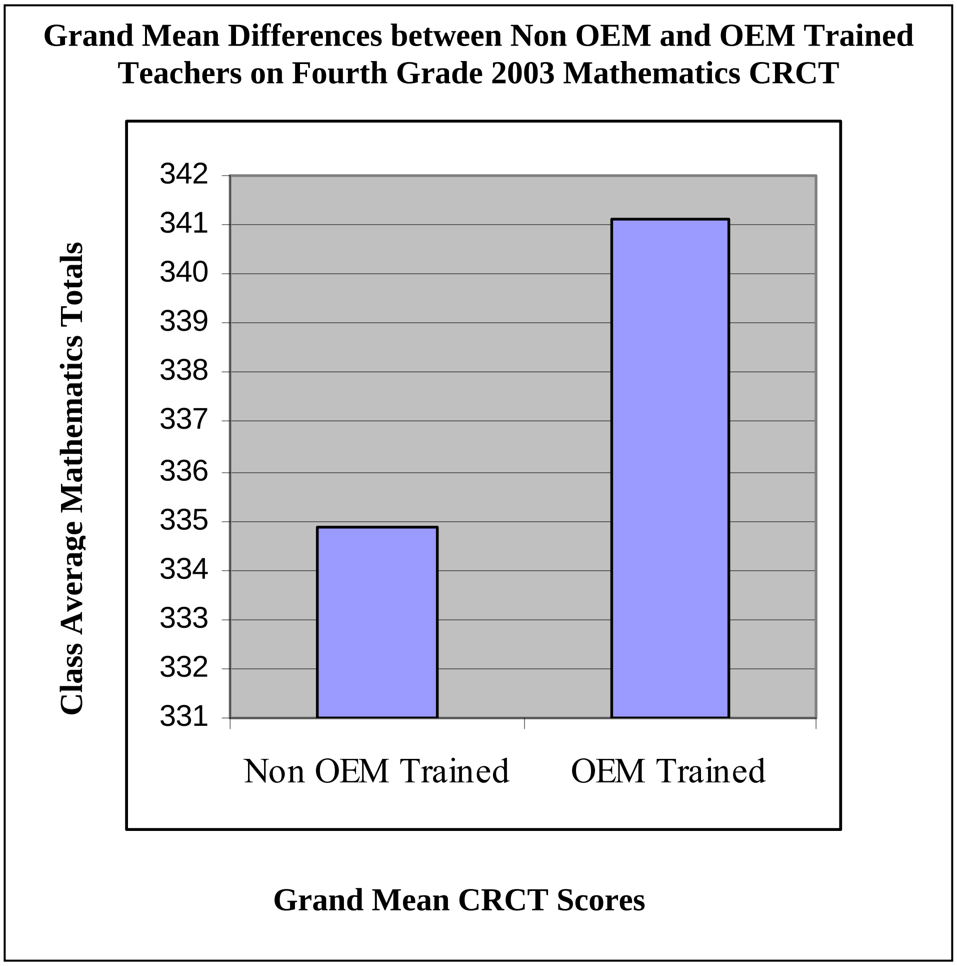
This numerical value, .48, shows in standard deviation units, how much better the class averages in mathematics achievement scores were for teachers who had received training in *Opening Eyes to Mathematics* than for those who had not. The .48 effect size shows that the average teacher in the experimental group had a class average .48 standard deviations higher than the average teacher in the control group. Since we know that 34% of all scores fall between the mean and +1 standard deviation, .48 represents approximately 16% of the scores. That would be like moving a class average from the 50th percentile to the 66th percentile on achievement tests.

Effect sizes do not have an automatically implied practicality, but researchers who have worked with effect sizes consider them to begin to have practical implications somewhere between .270 and .275 (Bracey, 1997). Therefore, an effect size of .48 can be used with moderate practicality to describe the difference in standard deviations between the two groups of teachers in the study.

The bar graph in Table 6 shows the grand mean differences between non-OEM trained and OEM trained teachers as measured by class average mathematics totals. The graph shows an increase from ~335 for non-OEM trained teachers to ~341 for OEM trained teachers, an increase of ~6 points.

Table 6

Grand Mean Differences between Non-OEM and OEM Trained Teachers on Fourth Grade 2003 Mathematics CRCT



In interpreting the results, the descriptive statistics indicated that the group of teachers who have been trained in *Opening Eyes to Mathematics* have a 6.22 point higher grand mean score than that of the group of teachers who have not participated in the training. An emphasis was placed on examination of the data provided by the t-test to determine whether or not there is a statistical significance between the mean scores of teachers trained in the *Opening Eyes to Mathematics* program and those who have not. The Levene test showed that the two groups of class average scores are homogeneous in variance. The alpha level of 0.05 in the t-test indicates a statistical difference in the two groups. The results of the study indicate that teachers who have been trained in the OEM program have class averages that are, as a group, statistically significantly higher than those who have not received the training.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This chapter presents a summary of the study. Conclusions and implications for further research, based on the results of this study, are also presented.

Summary

The focus of this study was centered on one specific professional development opportunity for teachers, *Opening Eyes to Mathematics*, and whether or not it made a difference in their students' mathematics achievement scores on the Georgia CRCT. Two groups of teachers were randomly selected after having been identified as teaching fourth grade in a selected large suburban school district in the 2002-2003 school year. One group received training in the *Opening Eyes to Mathematics* program, a constructivist-based philosophy of learning for children. Rather than using a programmed approach with textbooks and correlated sets of worksheets, the *Opening Eyes to Mathematics* philosophy is a hands-on, interactive approach presented in lessons developed to encourage children to think visually and represent their learning both verbally and non-verbally. The other group of fourth grade teachers did not participate in this training. Class average achievement scores for 90 teachers were examined; 45 did not receive training in *Opening Eyes to Mathematics* and 45 teachers did participate in this training. Data were collected regarding gender, certification level, years of experience, and National Board certification for teachers in the study.

Randomized descriptive statistics was the model incorporated for this study that examined mathematics achievement data as reported by class averages between the two groups of teachers. Mathematics test score data for this study were collected for the 2002-2003 administration of the fourth grade Georgia CRCT. Data for both groups of teachers were collected using the district's SASI and StART data reporting tools. Class average scores for teachers who have received OEM training were compared to class average scores for teachers who have not received the training. The dependent variable in the study was the teachers' class average achievement data in mathematics as reported by the CRCT scores. The independent variable was training or non-training of teachers in those classrooms.

The null hypothesis for the study was that the class average achievement scores in mathematics would not show a significant difference between classes of trained teachers and those who did not receive the training. In addition to the descriptive statistics analysis, a t-test and a Levene Test for Homogeneity of Variances was conducted. An effect size was also calculated.

Based on the results of this study, the researcher rejected the null hypothesis and concluded that the *Opening Eyes to Mathematics* professional development contributes to higher academic achievement scores in mathematics for teachers who participate in the training than for those teachers who do not. The data show an effect size that indicates teachers with OEM training have class average scores almost half a standard deviation higher than those who do not on the mathematics portion of the state achievement test. These findings have significant implications for the scheduling of professional learning opportunities for teachers and for the related academic achievement of their students in mathematics. The school system in which the study was conducted places a great deal of emphasis on the use of data to guide decisions about staff development. Until this study, no statistically reliable evidence has been available regarding the effectiveness of the *Opening Eyes to Mathematics* professional learning. This study provides valuable information regarding a training opportunity for teachers that is linked to improved student achievement.

Conclusions

The descriptive statistics analysis revealed that teachers who have received training in *Opening Eyes to Mathematics* had a grand mean of 341.1191. Teachers without the training had a grand mean of 334.8902, a difference of 6.2289. A 95% confidence interval for the mean infers that this holds true for the normal population. After examination of the t-test, the researcher rejected the null hypothesis based on a significance level of $\alpha = .029$. This P value indicates that there is a statistically significant difference in the class average achievement scores for the two groups of teachers. Class average achievement scores in mathematics are higher for teachers who have received the OEM training than for those teachers who have not been trained. The calculated effect size of .48 shows the magnitude of the difference.

The results of this study support the literature on the teaching practices of effective teachers. Research has suggested that one of the factors that matters most for student achievement on standardized tests is the instructional practices of the teacher (Clark, 2002). These findings support the research that indicates that improving the effectiveness of teachers can do more to improve education that any other single factor (Wright, Horn, & Sanders, 1997). In terms of closing the achievement gap, two pieces of the success puzzle include strategies such as changing curriculum and instruction and improving teacher preparation and professional development (Braverman, 2001).

Because the *Opening Eyes to Mathematics* philosophy involves an engaging, interactive approach, students become authentically engaged as opposed to ritually engaged or simply compliant. Without authentic engagement, learning and conceptual understanding cannot occur at maximum levels (Schlechty, 2002).

Finally, because *Opening Eyes to Mathematics* is manipulative based, the literature is again supported. Students who use manipulatives in their mathematics classes usually outperform those who do not (Driscoll, 1983; Sowell, 1989; Suydam, 1986).

Recommendations

Based on the findings of this study, and after a review of the assumptions and limitations of this research, there are several recommendations presented for further study:

1. A similar mathematics program, *Visual Mathematics,* was developed by the Math Learning Center as well. It is a companion sequel to the *Opening Eyes to Mathematics* program and is targeted for grades five through eight. A study should be conducted to determine whether teachers trained in the *Visual Mathematics* program have higher class average achievement scores than teachers who have not received the training.
2. The *Opening Eyes to Mathematics* program incorporates a set of philosophical beliefs about the way children learn mathematics. One of these beliefs centers on students' writing about the mathematics ideas in the lessons. A study should be conducted to investigate the effect of children's writing skills on mathematics achievement.
3. A study should be conducted to investigate the effects of student reading level on mathematics achievement.

4. A study should be conducted to examine student achievement scores in mathematics for students who have been identified with exceptionalities and whether or not their teachers have received training in *Opening Eyes to Mathematics.*
5. A study should be conducted to examine student achievement scores in mathematics for students who have been identified as ESOL (English for Speakers of Other Languages) or NEP (Non-English Proficient) and whether or not their teachers have received training in *Opening Eyes to Mathematics.*

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APPENDIX

Table 7

CRCT Scores for Two Teacher Groups: Non-OEM Trained and OEM Trained

NonOEM	Avg4CRCT	OEM	Avg4CRCT
1	331.36	2	339.86
1	350.26	2	350.48
1	330.73	2	302.82
1	351.00	2	309.38
1	331.74	2	321.88
1	342.95	2	322.08
1	350.15	2	353.10
1	347.59	2	343.15
1	325.63	2	332.43
1	332.14	2	331.71
1	346.31	2	349.13
1	341.86	2	338.00
1	327.36	2	334.71
1	337.55	2	343.75
1	351.70	2	352.57
1	340.62	2	337.88
1	336.11	2	348.83
1	328.69	2	341.50
1	343.25	2	345.40
1	317.61	2	361.83
1	352.05	2	344.00
1	332.29	2	334.00
1	322.25	2	323.00
1	318.51	2	321.53
1	323.23	2	351.65
1	344.18	2	347.56
1	317.16	2	343.31
1	317.95	2	355.47
1	348.87	2	354.10
1	329.29	2	363.30
1	327.42	2	328.80
1	312.29	2	330.94
1	331.63	2	335.95
1	341.71	2	354.65
1	347.81	2	333.19

1	348.42	2	325.36
1	337.40	2	369.20
1	300.64	2	339.13
1	319.05	2	351.00
1	330.87	2	351.32
1	321.30	2	347.21
1	350.85	2	346.05
1	355.57	2	347.14
1	328.36	2	337.90
1	346.35	2	354.11
Average	334.8902		341.1191

The first two columns show 45 teachers who have not received OEM training and their class average scores for the mathematics portion of the fourth grade. The next two columns show the same information for the 45 teachers who have received the training.

Table 8

Gender and Total Years Experience for Non-OEM Teachers and OEM Teachers

Non OEM Teachers	Gender	Total Yrs Exp	OEM Teachers	Gender	Total Yrs Exp
1	F	26		F	7
2	F	30		F	11
3	M	8		F	7
4	F	19		F	17
5	F	22		F	14
6	F	3		F	6
7	F	9		F	7
8	F	10		F	11
9	F	27		F	19
10	F	13		F	12
11	F	29		F	15
12	F	5		F	25
13	F	11		F	25
14	F	22		F	14
15	F	26		F	8
16	F	13		F	15
17	F	6		F	5
18	F	4		F	9
19	M	9		F	31
20	F	6		F	22
21	F	11		F	28
22	F	7		M	6
23	F	5		F	24
24	M	13		F	19
25	M	8		F	8
26	F	3		F	4
27	F	12		F	19
28	F	16		F	6
29	F	4		F	9
30	F	5		F	6
31	F	12		F	16
32	F	3		F	25
33	F	21		F	21
34	F	25		F	3
35	F	7		F	16
36	F	4		F	15
37	F	25		F	7
38	F	7		F	6
39	F	27		F	30
40	F	24		F	14

41	F	7	M	11
42	F	5	F	6
43	M	12	F	17
44	M	4	F	19
45	F	19	F	6
Average		13		13.8