The Influence of Teacher Preparation Programs on Student Achievement and the Use of NCTM Standards and Principles in Middle School and High School Algebra I Classrooms

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THE INFLUENCE OF TEACHER PREPARATION PROGRAMS ON STUDENT ACHIEVEMENT AND THE USE OF NCTM STANDARDS AND PRINCIPLES IN MIDDLE SCHOOL AND HIGH SCHOOL ALGEBRA I CLASSROOMS

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Abstract

The impact of traditional and alternative teacher preparation programs on student achievement and the instructional delivery methods used in middle school and high school Algebra I classrooms was explored through a mixed method comparative design. The data analysis revealed that alternative teacher preparation programs are a viable avenue to explore in meeting the needs of public schools for providing qualified teachers in mathematics classrooms at the middle school and high school levels. Data from the standardized state test and district level quarterly assessments revealed no significant differences between groups on half of the achievement measures, but there was a significant difference favoring the alternative preparation teachers on two of these measures. Only on one achievement measure, administered early in the school year, students of traditionally trained teachers outscored students of alternatively trained teachers. Furthermore, classroom observation data suggested teachers did not frequently implement instructional strategies based on NCTM standards or principles regardless of the type of training program.
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"Whether or not you reach your goals in life depends entirely on how well you prepare for them and how badly you want them.”  
(Ronald McNair, 1950-1986)

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Chapter One: Introduction

From 1642, the time most historians recognize as the start of public education, to present day, the role of the American public school has continued to evolve and to expand (Jackson, 1995). Though there has been considerable debate between policy makers, educators, parents, and interested citizens concerning what components create a quality education for all students, the citizens of the United States basically agree that public school systems in America must provide educational opportunities that enable every student to become a productive citizen in American society. Through a variety of educational reform measures, public school systems have continuously revamped their curriculum and instructional approaches in order to provide equitable educational opportunities to a diverse student population. However, there has been little agreement on whether these efforts have actually benefited all students being served by public education (Bol, 2004). In spite of numerous reform efforts, achievement gaps between Caucasian students and students of other ethnic groups continue to exist and the United States continues to lag far behind other industrialized nations in academic achievement (Leonard, Blasik, Dilgen, & Till, 2003). A consensus has not been reached among policymakers and educators regarding the components of an educational program that will ensure each child reach the level of academic achievement that will allow him or her the opportunity to fully compete in a global economy.

Over the past two decades, there has been a growing emphasis on holding public schools accountable for the academic performance of the students being served. During his first presidential term, George W. Bush's administration presented the nation with the No Child Left Behind Act of 2001. The No Child Left Behind Act (NCLB) became law
in January 2002 and requires that within the next twelve years, all students receiving a public school education should perform at or above a certain level of academic proficiency in reading, mathematics, and science. By the 2005-2006 school year, NCLB requirements will be in full effect for all American school systems. States will be required to show adequate academic development through tests that are administered to all students in grades 3 through 8 in mathematics and reading (Lin, Baker, & Betebenner, 2002). By 2007-2008, state tests must show that students are performing at a level of academic proficiency or higher in science. The assessments used by each state must be aligned with the standards established by the state and student achievement for each academic area must be compared from year to year to determine the rate of yearly progress (Goertz & Duffy, 2003).

Also, in an effort to maintain a standard level of accountability, NCLB requires that a teacher who is certified in the curriculum area that he or she is teaching only instruct students in that particular curriculum area. By June 2006, each classroom in the United States must offer students a highly qualified teacher as their instructor. In order to be considered as a highly qualified teacher, an educator must hold a minimum of a bachelor's degree, pass state tests of competency in the subjects that he or she is teaching, and hold full state licensure or certification (Linn, Baker, & Betebenner, 2002).

**Background of the Problem**

With the passage of No Child Left Behind (2001), all school systems in the United States, regardless of their student population, must seek the best instructional strategies and resources to meet school district goals and federal mandates for academic achievement. To ensure that “no child is left behind”, perhaps the resource that needs the
closest examination is the teaching force available to the school districts of this nation. In order for academic achievement to occur, someone must be able to teach the children what it is that they need to know (Pogrow, 2001). With this thought in mind, one must take into consideration that there has been growing concern regarding a lack of qualified teachers available to educate the students attending the nation’s public schools.

Schools will need more than two million teachers over the next decade to fill the vacancies created by retirement and those exiting from the field of public education (Howard, 2003). While the supply of teachers throughout the 1990s increased tremendously and the number entering the pool of new teachers each year has been adequate to meet the demands of the nation’s school districts, rates of retirement and teacher attrition seriously contribute to the frustration of maintaining a highly qualified teaching staff for every school in the country (Walker, 2003). Retirement will account for approximately 28 percent of newly created teaching vacancies. Within the next 10 years nearly 700,000 teachers will retire. In addition to retirement, attrition has been increasing steadily throughout the 1990s. In the 1999-2000 school year, 232,000 teachers who had not held teaching positions the year before were hired. In the following year, more than 287,000 teachers exited the schools. Based on the 2001 data from the National Center for Education Statistics (NCES), Walker (2003) found that nearly one-third of all new teachers in the United States leave the teaching field within their first three years of teaching and almost 50 percent may leave within the first five years of their teaching career. Thus, teacher attrition is a far more significant factor contributing to the shortage of qualified teachers to meet NCLB needs than retirement. However, the
combination of both factors can have a significant impact on our schools and the students that are served within them (Walker, 2003; Howard, 2003).

Since all students are entitled to a highly qualified teacher by the 2005-2006 school year, school districts throughout the country must have access to highly qualified educators. The areas of critical need in education are mathematics, science, and special education. Within the fields of mathematics and science, teachers with certification in these areas often leave the public school sector for the business sector at a rate of 28 percent (Howard, 2003). The lack of qualified teachers in the fields of mathematics and science seriously impact the instruction that students receive in these academic areas and undermines the future earning potential of the students not receiving their instruction from a qualified instructor.

Studies by Sanders and his colleagues at the University of Tennessee found that three consecutive years of inferior teachers can have a detrimental impact on students that last for several years (Viadero, 2000). While not all areas of the country and not every school district has difficulty attracting and retaining qualified teachers, the issue of the availability of qualified teachers in some areas of the United States is of great concern and deserves considerable attention as the nation moves forward in its attempt not to leave any child behind academically. The Northwest, the Rocky Mountain area, the Northeast, the Mid Atlantic region, and Alaska have a surplus of certified teachers. However, southern and western states have felt the severity of the qualified teacher shortage, which may in part be attributed to the rapid growth of the population over the past ten years. In California alone, one in every seven teachers is under qualified and instructing students with emergency certifications. Texas, Louisiana, Florida, Nevada,
and North Carolina have a great demand for certified teachers and are offering emergency credentials as well. Thus, many students enrolled in mathematics and science courses are receiving their instruction from a teacher who lacks state level certification within mathematics and science. Receiving instruction from teachers without the appropriate training in content knowledge and an awareness of instructional strategies that best meet student needs may have a negative impact on the academic development of a student in that subject area (Howard, 2003; Viadero, 2000).

While it is important to have a qualified teacher for every subject area, mathematics and science instruction are areas of critical need that require teachers who have considerable expertise in a wide range of subject matter, instructional strategies, and methods of assessment in order for students to make significant academic gains. Mathematics instructors train students who can contribute to strengthening the mathematical and scientific infrastructure of this nation, therefore every public school student needs to possess a strong mathematical foundation in order to attain future economic success. This goal can only be achieved through the equal availability of a high quality mathematics curriculum taught by highly qualified instructors (Schoenfeld, 2002). Recent federal research has revealed that the greatest factor for determining whether young people earn a bachelor’s degree is a strong academic curriculum at the high school level. Furthermore, advanced placement courses in mathematics beyond Algebra II are courses that are highly recommended by college admission advisors for academic success at the college level (Viadero, 2000).

Since mathematics has been the portal to lead students to technological literacy and higher education, it is easy to see the urgency in meeting the needs of all students in
the nation's mathematics classrooms. Meeting these needs must begin with the availability of a qualified teacher in every mathematics classroom with the support of a strong mathematics curriculum. Therefore, students that are more readily denied access to higher-level mathematics miss vital opportunities to gain essential skills. The lack of these essential mathematics skills may contribute to disenfranchisement and economic instability for these students (Schoenfeld, 2002).

The National Council of Teachers of Mathematics

The National Council of Teachers of Mathematics (NCTM) has developed standards across grade bands from kindergarten through 12th grade. *The Principles and Standards for School Mathematics,* set forth by the National Council of Teachers of Mathematics (NCTM, 2000), are a set of recommendations for what students should know and be able to demonstrate in mathematics across grade level bands. In addition to guidelines for student learning, NCTM identifies instructional delivery approaches and classroom practices that promote student achievement in mathematics (NCTM, 2000). Forty-nine of the fifty states in the United States rely heavily on the standards and principles promoted by this organization in order to establish state mandates and instructional guidelines in the area of mathematics (Schoenfeld, 2002). The focus of NCTM has been to improve mathematics education for all students (NCTM, 2000).

An examination of instructional strategies and assessment practices utilized by educators in a mathematics classroom should reflect high expectations and continuous support for all students. Student achievement in mathematics can be expected when the following components are in place: a clear and focused mathematics curriculum across all grade levels, an understanding of what students already know and what they need to
learn, an ability to build new knowledge into students’ existing experiences and prior knowledge, assessment that readily supports current and future learning, and technology that enhances students’ learning and performance (NCTM, 2000).

Schools that actively adhere to these principles and standards should be equipped to assist students in meeting the expectations of advanced mathematics courses. According to NCTM, the classroom environment must consist of active participation from students, a variety of hands-on activities, real-world problem solving, and a multitude of ways to assess student understanding of the concepts presented in class regardless of prior knowledge and academic ability (NCTM, 2000; Schoenfeld, 2002). Instruction within the classroom cannot be limited to pencil and paper activities and numerous sessions of lecture with the focus on teacher demonstration. Students should play an active role in explaining the rationale behind their responses while the teacher acts as a guide in the process of learning. Teacher decisions about the path of instruction to follow should be based on their knowledge of student learning and a variety of student assessment results (NCTM, 2000). In order for the NCTM standards and principles to be in effect in our nation’s classrooms, teachers need adequate training and exposure to these standards and principles.

**Teacher Preparation**

In a study exploring the connection between classroom practices and student academic performance, research findings suggested that the teacher’s characteristics and classroom practices had just as much impact on student learning as the students’ own characteristics and willingness to learn (Wenglinsky, 2002). Research supports the importance of providing students with highly qualified teachers in order to ensure
academic success, but there is a growing debate surrounding the manner in which teachers are trained in order to obtain the level of quality required by state mandates and NCLB guidelines. The question that tends to arise is which teacher preparation programs best prepare future educators for the challenges of instructing students in their core subject classes: traditional college teacher preparation programs or alternative teacher preparation programs?

Correlational analysis of data at the state-level by Darling-Hammond found that states with a high number of uncertified teachers showed negative correlations with student performance on state assessments in six different areas identified by the National Assessment of Educational Progress (NAEP) (Laczko-Kerr & Berliner, 2003). In addition to questions about uncertified teachers instructing students, there is a concern about the quality of teachers that receive certification through alternative teacher preparation programs as opposed to traditional college programs. In the state of Arizona, one in every six teachers is not certified in the subject matter of the course being taught. A study conducted by Laczko-Kerr and Berliner (2002) examined teacher effectiveness in relation to the different types of teacher training Arizona educators participated in prior to their entry into the classroom. The research concluded that students performed better in all academic areas when they were instructed by certified teachers that received their training in long term teacher preparation programs like those offered by colleges and universities as opposed to under certified teachers that received their training in short term teacher preparation programs, such as Teach for America (Laczko-Kerr & Berliner, 2003).
On the other hand, there is a body of literature that highlights the benefits of alternative teacher preparation programs. In the state of California, there were twenty-one California universities sponsoring alternative teacher preparation programs by 1991. The teachers prepared through these alternative programs, supported by the school systems and the university, were perceived as being just as effective and as well prepared as those teachers trained through traditional college teacher preparation programs. The academic achievement of the students instructed by the teachers trained in the alternative programs did not significantly vary from the academic achievement of students instructed by teachers trained in traditional teacher preparation programs (Newman & Thomas, 1999). Also, research findings from a late 1980’s study in Texas found that university-based alternative teacher preparation programs produced teachers which passed the state-mandated teacher exam at a higher percentage rate than teachers trained in traditional teacher preparation programs. In addition, the attrition rate among the alternatively trained teachers was lower than the attrition rate among the traditionally trained teachers in the Texas study (Newman & Thomas, 1999). In the states of California, Texas, and New Jersey alternative teacher preparation programs have been used extensively since the mid-1980s to provide teacher licensure to new educators entering the field. These alternative preparation programs have had a positive impact on increasing the number of teachers of color and men as well as recruiting and retaining highly qualified individuals from other professions (Feistritzer, 1999).

**Statement of the Problem**

There is a body of research that suggests the differences in achievement among public school students is not related to the ability to learn, but the greatest contributing
factor may be the quality of instruction (Viadero, 2000). Research suggests that employing a wide variety of instructional strategies greatly benefits all students (NCTM, 2000). Though reform measures for mathematics are in place throughout the public schools of the United States, there is still an overwhelming achievement gap that exists between Caucasian students and African American, Hispanic, and Native American students in regard to higher-level mathematics coursework (Checkley, 2001; Schoenfeld, 2002). If teachers are using the instructional strategies encouraged by educational reform efforts, there should be continuous, gradual improvement in mathematic achievement for students of every ethnicity in Algebra I and higher-level mathematics courses. However, in order for students to experience these strategies mathematics teachers must be highly qualified and have exposure to these research based instructional strategies (NCTM, 2000; Checkley, 2001). Teachers need time and continued support to implement strategies effectively (Bol, Ross, Nunnery, & Alberg, 2002). If NCLB is to be a success, qualified teachers are needed to promote student achievement. Also, an understanding of the type of teacher training, alternative or traditional, linked to effective instruction and student achievement is an important step in supplying the nation with teachers that possess the crucial skills needed to provide students with the instruction that will allow each student to meet the academic goals set forth by the guidelines of No Child Left Behind.

Urban Implications

Suburban and rural school districts are just beginning to feel the effects of teacher shortages in the areas of mathematics, science, and special education. Low-income areas in urban school districts experience higher rates of teacher turnover and greater difficulty
with obtaining qualified teachers. Also, urban school districts tend to struggle with retaining an experienced and certified teaching force (Kozol, 1991; Viardo, 2000). Urban and low-income area students are far more likely to be taught by poorly prepared and non-certified or under certified instructors (Viadero, 2000). In a 2001 report by Recruiting New Teachers, Inc., the Council of the Great City Schools, and the Council of the Great City Colleges of Education revealed that the largest urban school districts of the nation would feel the impact of teacher shortages more than any other school districts (Howard, 2003).

The distribution of teacher talent throughout the United States remains uneven as well. The most qualified and highly certified teachers are hired by more affluent and suburban school systems; while the least qualified teachers are often employed by urban school districts with high poverty populations (Blair, Hoff, Keller, & Manzo, 2002). Urban school districts in the United States have the highest concentrations of poor, minority, and immigrant students (Carbo, 1995). Within these urban schools, the classes with the greatest number of low achieving students usually receive the most ill prepared teachers (Ingersoll, 2002). One of every five secondary courses in core content subjects is taught by a teacher without a major or a minor in the academic field being taught. In high poverty areas, which significantly impact urban areas, there is a three to one ratio of core academic courses being taught by unqualified teachers (Haycock, 2003). Therefore, urban school districts will have the most difficulty filling mathematics and science classes with well-trained teachers. Mathematics and science classes are core subjects that urban students tend to lag far behind in when compared to their suburban counterparts. A
shortage of qualified teachers in these subject areas will further widen this disparity (Howard, 2003).

**Significance of the Study**

An important contribution of this research is to add to the body of knowledge on teacher preparation programs, instructional strategies used in mathematics classrooms, and student achievement in mathematics. There are a number of studies that have examined a variety of alternative teacher preparation programs and their impact on teacher preparedness, student achievement in a variety of subject areas, and the frequency of the use of effective instructional strategies for diverse student populations. However, there has been little research comparing traditional teacher preparation programs to an alternative teacher preparation program in relation to student achievement, instructional strategies used in Algebra I classrooms, and the level of understanding teachers demonstrate through classroom practices in regard to the principles and standards set forth by the National Council of Teachers of Mathematics. Research evidence is presented that provides a more in depth look at the impact of teacher preparation on the level of academic achievement for students in middle school and high school level mathematics courses. A better understanding of the aspects of teacher preparation programs that best prepare teachers for meeting the demands of developing student understanding for a variety of mathematical concepts could benefit traditional teacher preparation programs at the college and university level, alternative teacher preparation programs, and professional development courses provided by school systems.

An additional benefit of this research is the identification of the instructional strategies that are most widely used in mathematics classrooms by educators with...
different teacher preparation experiences. The information may provide assistance to school systems in meeting the needs of the students as well as its teachers by identifying the instructional strategies that are utilized in mathematics classrooms that most positively impact academic achievement among students. This information could be used as a catalyst for addressing existing achievement gaps in mathematics among various student populations. A final benefit of this research is to promote a better understanding by all teachers of the principles and standards set forth by NCTM and their relationship with student achievement, instructional practices, and state standards. An understanding in this area could provide guidance for school improvement plans, professional development opportunities within the school district, and curriculum development initiatives.

The study addresses an urban issue because poor performing schools, inexperienced teachers, and academically at-risk student populations are heavily concentrated in inner-city schools. Often the least experienced teachers with the least amount of content knowledge for the subject area being taught are placed in the poorest districts and in schools with the highest concentration of disadvantaged youth (Blair et al., 2002). Urban school districts experience great difficulty in attracting and retaining an experienced and certified teaching force, especially in the areas of mathematics, science, and special education. Often schoolhouses with a high concentration of poverty, minority, and immigrant students have the largest number of under certified and non-certified teachers (Howard, 2003). Furthermore, the lack of qualified teachers may cause some schools to limit their offerings of advanced mathematics courses, which would limit
student access to the quality education that is promised to each student by the standards established by No Child Left Behind.

**Purpose and Overview of the Study**

The study examined the instructional delivery methods used by beginning teachers that received their training in a traditional teacher preparation program of a college or university compared to the instructional strategies used by beginning teachers that have received their teacher training in the alternative teacher preparation program, Transition to Teaching. The study focused on the impact of teacher preparation and instructional strategies used by beginning teachers on student achievement in Algebra I classrooms at the middle school and high school levels with regard to national standards in mathematics.

For the purpose of this study, a traditional teacher preparation program is a four or five year undergraduate program at the college or university level that offers students coursework in teaching methods as well as content knowledge for the area of subject concentration selected by the student. Traditional teacher preparation programs for this study are characterized by the participant obtaining a bachelor's or master's degree in education with an emphasis in a particular area of study (Darling-Hammond, 2000).

The Transition to Teaching program provides training to individuals interested in entering the field of teaching, but have not received degrees in education. Potential participants must have the following upon entry into the program: a 2.5 grade point average or higher in all college coursework; a bachelor's degree or higher from an accredited college or university with courses in English, mathematics, social studies, and science or a bachelor's degree or higher from an accredited college or university with
work experience related to English, mathematics, social studies, and/or science; a qualifying score on the Praxis I series of tests that meets the licensure requirements of Virginia in the area of reading, writing, and mathematics; and a qualifying score on the Praxis II content test with qualifying scores for a Virginia teaching license. In addition, participants interested in the program must meet the requirements for employment as a public school teacher in the state of Virginia (Transition to Teaching, 2004).

The Transition to Teaching program requires qualified candidates to participate in a four week Summer Institute that focuses on education coursework and to obtain a Virginia Professional License with an endorsement in secondary content areas, such as secondary English, mathematics, social studies, or science. Also, participants receive financial support as they pursue a master’s degree in special education or literacy education. Each participant is expected to commit to teach for three years in the urban school district where they received their training (Transition to Teaching, 2004).

The present study addresses the following three research questions: (1) Does the type of teacher training impact the academic achievement of students in mathematics?; (2) Does teacher preparation impact the implementation of the process standards set forth by the NCTM?; (3) Does the frequency with which teachers use process and content standards influence student achievement? These questions were examined through a series of classroom observations, a teacher questionnaire, and an analysis of quantitative data gathered on student achievement through district level quarterly mathematics assessments and Standards of Learning assessments from the state.

The study took place in an urban school district within Algebra I classrooms at the high school and middle school level. Throughout the second semester of the 2003-2004
school year, the researcher and members of the Transition to Teaching program used a classroom observational tool and a teacher questionnaire to collect data regarding the instructional strategies used in the classrooms of teachers prepared for their teaching assignments through traditional teacher preparation programs and the classrooms of teachers prepared for their teaching assignments through the alternative teacher preparation program, Transition to Teaching.

While the study design was strengthened through the use of varied data sources, there are limitations to this research design. The first limitation to address was the use of observations. The observations provided a way for the researcher to monitor what was occurring in the classroom. However, the presence of an observer may affect teacher and student behaviors. The observer's perception of the situation may distort the data as well. There is a certain amount of constraint in observations because only limited portions of the entire mathematics program can be observed and the focus is on the external behaviors of the participants.

A related limitation addresses instrumentation. The researcher developed both the classroom observational tool and the teacher questionnaire to collect data on teachers' use of instructional strategies. To enhance validity, blueprints based on the NCTM standards and principles were used to guide instrument development. Furthermore, the instruments were reviewed by experts in instrument development and mathematics instruction. Reliability for both measures was estimated. The observation tool was also pilot tested.

An additional limitation of the study was the number of study participants. Although teachers in both programs were matched, the threat of selection bias still exists, especially given the small number of teachers in each group. The groups of teachers
could have differed on other characteristics besides the type of preparation program. Also, the limited number of participants does not allow the researcher to make generalizations beyond the sample in the study. Thus, the findings of this study can only be generalized to the sample being observed. However, the findings contribute to the body of knowledge concerning the impact of teacher preparation programs on the academic achievement of students in mathematics courses and the type of instructional strategies used in mathematics classrooms that demonstrate an understanding of NCTM standards. Few studies have linked teacher preparation and NCTM standards to student achievement and the instructional strategies used in the Algebra I classroom.

Finally, the variation among traditional teacher preparation programs was a limitation of this study. While traditional preparation programs are generally characterized as programs that require four to five years of coursework in an accredited university or college setting, each traditional preparation program varies in the number of coursework hours designated for content knowledge and the number of coursework hours dedicated to instruction in teaching methods. This limitation must be taken into account since the participants of this study received training in traditional teacher preparation programs at various accredited universities and colleges in a variety of locations.
Chapter Two: Literature Review

Introduction

One purpose of this literature review is to address prior research comparing the effectiveness of teachers trained through traditional versus alternative teacher preparation programs on pedagogy and indices of student achievement. A review of the literature reveals both support for and opposition toward alternative teacher preparation programs as a way to address the nation's need to provide quality teachers for every classroom by the 2006-2007 school year. In addition, the literature addresses the process and content standards of the National Council of Teachers of Mathematics (NCTM) and how the utilization of these standards impact student academic achievement in mathematics.

Traditional Teacher Preparation Programs

A traditional teacher preparation program refers to a four or five year undergraduate educational program at the college or university level. Upon completion of the program, participants earn a bachelor's or master's degree in education with an emphasis in a particular area of study. The type of certification an individual receives at the state level depends upon the area of subject concentration undertaken during the four or five year teacher preparation program. Traditional preparation programs offer students training in teaching methods as well as content knowledge for the area of subject concentration selected by the program participant. Research conducted by Darling-Hammond (2000) and presented to the National Commission on Teaching in America's Future revealed that teachers trained in a five year traditional teacher preparation program that resulted in a bachelor's degree in a subject field and a master's degree in education entered the field of teaching at a rate of 90%. These teachers remained in a teaching
position after the first three years of teaching at a rate of 84%. This same research study found that teachers who completed a traditional four year teacher preparation program with a bachelor’s degree in either a subject area or in education entered the field of education at a rate of 70% and remained in a teaching position after three years at a rate of 53%. The evidence revealed by an analysis of statistical data suggests that teachers receiving long term training through college or university programs are more likely to enter and remain in the field of teaching (Darling-Hammond, 2003). However, it should be noted that the findings of Darling-Hammond (2003) are in direct contrast to the research of Newman and Thomas (1999), which found the attrition rate of traditionally trained teachers in Texas to be higher than the attrition rate among teachers completing an alternative certification program offered by the state.

Traditional teacher preparation programs provide individuals with methods courses that allow future teachers to learn pedagogical content knowledge necessary for quality instruction. As cited in Laczko-Kerr and Berliner (2003), empirical research conducted by Wilson, Floden, and Ferrini-Mundi in 2002 for the U.S. Department of Education suggested that teachers needed extensive training in order to develop a deeper knowledge of subject matter and the ability to teach this subject matter to a diverse student population. The literature suggests that the training and coursework provided in most traditional teacher preparation programs is necessary for promoting student achievement.

Laczko-Kerr and Berliner (2003) reviewed the literature and conducted a study comparing the performance of under certified teachers (those with emergency licenses and alternative teacher preparation training) and certified teachers (those teachers with
teacher preparation training through traditional college or university programs) in the state of Arizona. In Arizona, one in every six teachers is not certified in the subject matter of the course being taught. These teachers have been awarded emergency licenses for teaching and have received training through alternative programs in order to prepare for the delivery of classroom instruction (Laczko-Kerr & Berliner, 2003). The researchers utilized data from classroom observations and student assessment scores to determine the impact of teacher training on classroom instruction. The research findings suggested that teachers completing traditional preparation programs with training in pedagogy performed better in the area of classroom instruction than teachers trained in alternative preparation programs. Additionally, the researchers concluded that students performed better in all academic areas, as evidenced by report cards and assessment scores, when they were instructed by certified teachers that received their training in long term teacher preparation programs like those offered by colleges and universities as opposed to under certified teachers that received their training in short term teacher preparation programs (Laczko-Kerr & Berliner, 2002).

Furthermore, evaluations conducted by supervisors regarding the performance of teachers in the classroom were more favorable for teachers prepared for teaching through traditional teacher preparation programs. In 1993, researchers Ferguson and Womack found that 16 percent of the variance in supervisor evaluations regarding teacher performance was attributed to the amount of educational coursework a teacher had received. In addition, the variance that Ferguson and Womack found for teacher content knowledge scores on the National Teachers Examination specialty area was not as great as the variance explained by coursework. Education coursework was a stronger predictor
of teaching effectiveness than content knowledge test scores (Laczko-Kerr & Berliner, 2003). Teachers with less experience and inadequate training seemed to need exposure to the instructional strategies and content knowledge offered through a traditional college preparation program (Black, 2003). In a 2001 Colorado study of 237 first year teachers prepared through traditional teacher preparation programs at universities and 154 first year teachers prepared through the Metro State College Teachers in Residence alternative teacher preparation program, survey results revealed that the teachers trained in the alternative preparation program expressed greater concerns in the areas of pedagogy and instructional preparation than teachers trained in traditional preparation programs (Wayman, Foster, & Mantle-Bromley, 2003). In a similar study of 41 alternatively trained educators matched with 41 traditionally trained educators with at least three years of teaching experience, interviews revealed that alternatively prepared teachers attributed their level of discomfort with effective lesson components (objective and purpose, goal direction, modeling, practice, monitoring, feedback, and closure) to their teacher preparation route (Miller, McKenna, & McKenna, 1998).

The instructional strategies utilized by the teacher and the teacher's knowledge of the content impact the academic achievement of students in any subject area. Wenglinsky (2002) found that student achievement within mathematics classes was influenced by both teacher content background and teacher education. He looked at how the mathematics achievement level of more than 7,000 eighth graders on the 1996 NAEP mathematics assessment were related to measures of teaching quality, teacher characteristics, and student social class background. Students in classrooms instructed by teachers who completed traditional methods courses in their content areas performed
better on NAEP mathematics assessment than students in classrooms instructed by teachers who did not complete traditional methods courses. Through his research, Wenglinsky (2002) concluded that teachers' pedagogical decisions and activity selections independently make a difference in a student's achievement. In addition, Wenglinsky found that the cumulative effect of the combined teacher quality measures had a greater impact on student achievement than a student's socioeconomic background (Wenglinsky, 2002).

However, extensive teacher training in a four or five year program does not guarantee an effective teacher. The characteristics of a teacher can be developed as the individual participates in a teacher preparation program, but these characteristics cannot be created within a program. In the text, No Excuses,Themstrom and Themstrom (2003) make reference to a study (Wright, Horn, & Saunders, 1997) that reveals only 3 percent of what impacts student learning and academic achievement is associated with teacher experience and degree attainment. While the authors agree that educational degrees beyond a bachelor's degree and experience are relevant, an analysis of California students in the public school system during the 1997-1998 school year revealed that there was no positive effect on NAEP scores for fourth and eighth grade students related to degrees beyond the bachelor's. Thus, traditional teacher preparation programs of four or five years in length that result in the attainment of a bachelor's in education, and a master's in a subject area, do not necessarily create effective classroom teachers.

**Alternative Teacher Preparation Programs**

With the passage of No Child Left Behind (NCLB, 2002), states will be faced with increased restrictions on their hiring practices. Each classroom must have a highly
qualified teacher in place by the 2006-2007 school year. A highly qualified teacher is defined as an individual that holds full state licensure and only instructs students in the subject areas for which he or she is endorsed. The NCLB guidelines allow individuals to receive full licensure through alternative preparation programs if the individual can meet the following criteria: demonstrate competency of the subject matter through the state professional teacher exam, holds a bachelor’s degree, is allowed by the state to perform the required duties of a regular classroom teacher, and agrees to complete all requirements for full licensure in a specified amount of time (Virginia Department of Education, 2003). In order to fulfill the need of supplying quality teachers in the classrooms of our public schools, the number of alternative teacher preparation programs has increased. Some literature suggests that alternative teacher preparations programs are negatively impacting student achievement and do little to alleviate the problems with teacher attrition and quality (Laczko-Kerr & Berliner, 2003; Darling-Hammond, 2003).

In contrast, other sources suggest that alternative teacher preparation programs that incorporate collaboration with school systems and universities produce teacher candidates that performed as well as traditionally trained teachers in the classroom. Teachers participating in alternative certification programs that require extensive monitoring components during a student teaching or practicum experience, post graduation training, regular professional development courses, and continuous university supervision have a positive impact on student achievement (Miller, McKenna, & McKenna, 1998). In a study examining the differences in teaching practices between those educated through traditional preparation programs and those educated through alternative preparation programs with the aforementioned components, forty-one
alternatively trained teachers were matched to forty-one traditionally trained teachers. An analysis of the data, which included interviews with the teachers, classroom observations, student scores on the Iowa Test of Basic Skills, and three additional mathematics assessments, found that there appeared to be no effect of type of teacher training on student achievement. Students in classes with alternatively trained teachers and students in classes with traditionally trained teachers did not show any significant differences in achievement based on reading and mathematics assessment scores (Miller, McKenna, & McKenna, 1998). When a school system-university partnership was established, alternatively trained teachers reported that they felt better prepared than some traditionally trained teachers in the area of instructional techniques and methods according to survey results (Newman & Thomas, 1999). In a case study of sixteen teachers (eight trained in an alternative certification program in Los Angeles and eight trained in traditional certification programs), six of the eight alternatively trained teachers felt that they were well prepared in delivering instructional practices that were meeting the needs of diverse learners as opposed to the other case study participants (Stoddart, 1993). In addition, alternatively trained teachers were more likely to enter teaching positions in urban and poor school districts at a rate much higher than those individuals trained in traditional teacher preparation programs. According to this case study of sixteen alternatively and traditionally trained teachers in Los Angeles, alternatively trained teachers were more likely than traditionally trained teachers to have higher expectations for poor and minority students, and attempt to develop curriculum and utilize instructional practices that address the needs of diverse learners (Stoddart, 1993; Zeichner & Schulte, 2001). There was little evidence to suggest that these alternatively
trained teachers opted to leave these urban and poor schools prior to the end of their first year or within three years of their teaching experience. Early data gathered in 1999 from the Center for Education Information revealed that individuals entering teaching through an alternative teacher preparation program have a higher rate of retention than those trained through traditional teacher preparation programs (Feistritzer, 2001). While this finding conflicts with Darling-Hammond (2003) whose findings indicated that the attrition rate of alternatively trained teachers was higher than the attrition rate of traditionally trained teachers, it should be noted that Feistritzer’s research findings pertain to alternative preparation programs that have a variety of standard and candidate requirements as well as student teaching, practicum, or field base experiences prior to independent instructional opportunities in the classroom environment. The aforementioned components were not a part of many of the alternative programs considered in Darling-Hammond’s study comparing traditional and alternative teacher preparation programs. An additional benefit of alternative teacher preparation programs was the substantial increase of ethnically/culturally diverse and male teachers entering the field of public education (Feistritzer, 2001). Also, alternatively prepared teachers may be more likely to teach critical need area subjects, such as mathematics and science, within large urban areas and in schools serving widely diverse student populations (Roach & Cohen, 2002). The findings from these studies suggest that alternative routes to teacher preparation are not only more effective in attracting and retaining male and ethnically/culturally diverse teachers in classrooms where the demand for teachers is greatest, but that these teachers enter the classroom as highly qualified individuals from other professions with a variety of real world experiences that can be applied to
classroom instruction (Feistritzer, 1999). Indeed, research findings suggest that the alternatively trained teachers were generally more receptive to the needs of the urban student (Newman & Thomas, 1999).

Due to the overwhelming number of alternative programs and the lack of consistency among the programs, researchers have had considerable difficulty evaluating the effectiveness of alternative education programs (Newman & Thomas, 1999). However, Feistrizer (1991) analyzed data from alternative teacher preparation programs in 39 states. Of the 39 states, only 11 states had alternative programs that were designed to bring highly qualified adults with bachelor degrees in related fields into the teaching profession. Teachers that entered teaching with these criteria showed a positive impact on student achievement and the teaching profession (Feistritzer, 1998). Alternative programs that positively impact student achievement, as evidenced through standardized assessments, adhere to standards and attract qualified candidates that already hold at least a bachelor's degree in a subject area related to the content of the subject being taught. Also, quality alternative preparation programs provide an instructional component that connects subject area knowledge to teaching standards and practicum or student teaching experiences. In addition, participants in alternative programs are required to pass the same licensure exams as traditionally trained teachers. Finally, quality alternative programs provide teachers with a well developed induction program, on-going professional development opportunities, and mentors (Roach & Cohen, 2002).

Successful alternative teacher preparation programs provide teachers with extensive field-based, in-the-classroom training and instruction. In a study exploring the connection between classroom practices and student academic performance, research
findings suggested that the teacher’s characteristics and classroom practices had just as much impact on student learning as the students’ own characteristics and willingness to learn (Wenglinsky, 2002). Alternative programs that offer a practicum and student teaching component or field based experience along with the guidance of a mentor or master teacher, and provide support from college faculty and peers demonstrate success in preparing teachers that meet the academic needs of a diverse student population.

**NCTM Standards and Principles as a Theoretical Framework**

The *Principles and Standards for School Mathematics* (NCTM, 2000) set forth by the National Council of Teachers of Mathematics is the model being used to examine the content knowledge and skills that students should have in algebra at the middle and high school levels. The guidelines written in this document serve as the theoretical framework which allows the researcher to examine the instructional delivery and assessment practices that need to be present in order to promote the development of the mathematical understanding that students need for academic success in mathematics, particularly in the area of Algebra I for this study (NCTM, 2000).

The National Council of Teachers of Mathematics (NCTM) is the foremost authority on mathematics instruction and assessment. The principles and standards set forth by the NCTM play a key role in the development of curriculum, instructional strategies, and assessment tools for public school systems throughout the United States. Research studies involving lesson reviews, classroom observations, student scores on standardized assessments, teacher and student interviews, and questionnaires with students and instructors reveal a positive impact on student achievement for mathematics.
programs that incorporate the principles and standards of NCTM (Ladson-Billings, 1994; NCTM, 2000; Weiss & Pasley, 2004).

Equity, curriculum, teaching, learning, assessment, and technology are the principles established by the NCTM that serve as a guide for school systems to follow in the development of a mathematics program that should benefit every student from pre-kindergarten through twelfth grade (NCTM, 2000; Joyner & Reys, 2001). The process standards set forth by the NCTM are problem solving, reasoning and proof, communication, connections, and representation. These process standards are applied throughout each of the content standards: number and operations, algebra, geometry, measurement, and data analysis and probability. The algebra content standards require students to demonstrate an understanding of patterns, relations, and functions, to represent and analyze mathematical situations and structures using algebraic symbols, to use mathematical models to represent and understand quantitative relationships, and to analyze change in various contexts. The process and content standards work in conjunction with the principles in the establishment of a mathematics program that addresses the needs of all students and promotes academic achievement in mathematics.

The process standards describe the mathematical competencies and understandings that students should possess after engaging in a mathematics program utilizing NCTM standards (NCTM, 2000). The process standards require the assignment of worthwhile tasks that encourage students to explore a multitude of problem solving strategies, apply skills in reasoning, and utilize a variety of avenues for solution, representation, and exploration in mathematical terms. According to NCTM, the discourse of the teacher plays a key role in helping students of all mathematical
backgrounds understand the concepts presented in class. The variety of instructional approaches used by the teacher to promote students understanding of key mathematical concepts should reflect that the teacher understands the academic needs of the students within the classroom. In turn, the discourse of the students should reflect the students' ability to apply reasoning skills and to supply proof for the solutions the students present in regard to the meaningful mathematical tasks presented in class. NCTM emphasizes the need for communication in oral and written form as an important process standard that allows students to engage in dialogue using mathematical terms to discuss their findings to other students and the teacher during cooperative group and independent tasks (NCTM, 2000). The communication between students and the teacher is enhanced through meaningful tasks that incorporate a variety of tools, which help students deepen their understanding of mathematical concepts while applying these concepts to the development of explanations, solutions, and representations of the findings. The learning environment of the classroom that incorporates NCTM principles and standards should encourage student participation and academic achievement by providing opportunities for remediation and enrichment whenever possible. Also, the learning environment created by the teacher should provide frequent feedback and follow up from the teacher to reinforce student understanding of the connections between previously addressed mathematical concepts and the concepts addressed in current course discussions, tasks, and solutions (NCTM, 2000; Weiss, I. & Pasley, J., 2004). In a classroom adhering to NCTM principles and standards, teaching and learning are continuously analyzed. Mathematics teachers actively monitor student learning through a variety of assessments and apply the instructional strategies that allow all their students to acquire and utilize
content knowledge presented in class (NCTM, 2000). As previously noted, research is reviewed in subsequent sections organized by each process standard. The research supports the possibility of the positive impact that the NCTM standards and principles may have on student achievement in mathematics.

**NCTM Process Standards**

**Problem Solving**

The first process standard, problem solving refers to the student engaging in tasks for which the solution is not known in advance. Students engaged in appropriate problem solving tasks need an opportunity to extend and solidify their knowledge as well as stimulate new learning and develop a range of strategies for problem solving. Teachers with an understanding of this process standard provide a classroom environment where students feel safe enough to explore and take risks, share failures and successes, and question one another (NCTM, 2000). Students need a learning environment that promotes collaborative experiences, utilizes culturally relevant resources, and encourages the utilization of a variety of problem-solving skills, higher-order thinking processes, and active participation throughout the class (Boykin, 2000). Hiebert (1999) examined 1996 NAEP data which revealed that students learn the most basic mathematical skills, such as adding, subtracting, multiplying, and dividing whole numbers, but have difficulty extending these skills to more complex problem solving applications. Only eight percent of eighth graders in the study were able to solve a multi-step problem on planning a trip that required calculating total miles, finding the distance based on miles per gallon, and determining fractional parts of a trip. The data revealed that due to the instructional methods teachers selected, the opportunities for exposure to activities that promote the
development of the skills necessary to solve multi-step problems were limited (Hiebert, 1999).

Students that are successful in mathematics engage in numerous meaningful tasks that allow the students a degree of flexibility to choose from a variety of computational strategies and explain their methods orally or in writing to support the accuracy of their answers (Boaler, 2002). A research study examined the effectiveness of the QUASAR project (a program developed for inner-city schools with a large limited-English speaking student population and unsatisfactory mathematics scores) through classroom observations, interviews with students and teachers, and student responses to questionnaires. The researchers studied mathematics instruction among teachers in six urban middle schools serving socially and culturally diverse populations of students in the United States. The teachers participating in this study spent 5 years developing and implementing a mathematics curriculum closely aligned with NCTM principles and standards (Boaler, 2002; Dove & Keller, 2004). While students continued to learn basic math facts and algorithms, they were also exposed to when, how, and why to apply procedures, which could be used to solve high-level problems. Researchers measured student academic performance over time and found that students participating in the QUASAR project made significant gains in mathematics achievement. Furthermore, these students performed at significantly higher levels than comparable student groups on a range of assessments. Additionally, the gains in mathematical achievement were equally distributed among the different racial, ethnic, and linguistic groups of students (Boaler, 2002; Dove & Keller, 2004).
In a quasi-experimental study examining problem solving, ad hoc tutoring, and student achievement in mathematics for students with learning disabilities, researchers conducted classroom observations and gathered student assessment results to determine the impact of incorporating instructional strategies involving problem solving. The data suggested that a combined focus on problem solving during tutoring sessions and the implementation of problems solving strategies in classroom instruction had a positive impact on student achievement based on ITBS (Iowa Test of Basic Skills) assessment test results, particularly in the sub-category of problem solving (Woodward, Monroe, & Baxter, 2001).

**Reasoning and Proof**

The reasoning and proof process standard refers to the student being able to reason inductively from patterns. Students learn how sensible math can be and produce mathematics proofs that reflect the student's understanding of the mathematical concepts presented (NCTM, 2000). A study of student learning among participants in the Connected Mathematics Project (CMP), which is a curriculum program for algebra based on NCTM content standards for algebra, examined the mathematical achievement of students that had three years of exposure to the CMP curriculum. The study utilized five pairs of eighth graders for the study who were middle to high achieving students. Through video recordings, interviews, and the written work of 10 students randomly selected in one middle school in the Midwestern United States, researchers found that all students demonstrated an understanding of algebraic concepts, an ease with the procedures for solving problems, competence in applying problem solving strategies, and an ability to reason and to explain their solutions (Krebs, 2003). In a study of 384
students at the eighth grade level in 12 eighth grade classes, the impact of cooperative learning and meta-cognitive training on student achievement was examined. Meta-cognitive training involves students working through a series of self-addressed questions, such as what is the nature of the problem of this task, what is the relationship between previous knowledge and new knowledge, and what strategies are appropriate for completing the task (Kramarski & Mavarech, 2003). Students that are successful in mathematics engage in numerous meaningful tasks that allow the students a degree of flexibility to choose from a variety of computational strategies and explain their methods orally or in writing to support the accuracy of their answers. Students that received meta-cognitive training outperformed students that did not receive the training. These students were better able to present mathematical proofs that reflected their understanding of the mathematical concepts presented in class (Kramarski & Mavarech, 2003). Thus, classroom instruction that places an emphasis on encouraging students to provide reasons for their responses and proof of the validity of their answers is an important component in mathematics instruction that promotes student achievement and concept understanding.

Communication

Communication is a crucial component in assessing and promoting student learning in the mathematics classroom. Students need opportunities to write about mathematics and to convince their peers of their reasoning approach and findings in oral and written form (NCTM, 2000). There is a concern that while educational reform in the area of mathematics places an emphasis on positive communication between teachers and students, there are still several lessons in mathematics that do not employ this process standard. A lack of emphasis on the communication process standard can negatively
impact academic achievement in the mathematics classroom. The Horizon Research team studied 364 lessons in mathematics and science over a period of 18 months as a part of a study to determine the quality of classroom instruction in grades kindergarten through twelve (Weiss & Pasley, 2004). The lessons were recorded, analyzed, and assessed based on the mathematics and science content provided, the effectiveness of the implementation of the concepts in the classroom, and the degree to which the climate of the classroom encouraged student learning. Poor quality lessons were those lessons that did not engage all students in communication with peers and the teacher in class. The researchers found that 59 percent of the lessons were rated as poor quality in kindergarten through twelfth grade mathematics and science lessons. While nearly half of the lessons provided access to instruction and feedback for all students, 29 percent of the lessons were still rated as poor in this area because of the multitude of incidents where the teacher did not include all students in the lesson (Weiss & Pasley, 2004). Furthermore, in poor quality lessons teachers did not adjust instructional delivery methods to encourage student participation and understanding (Weiss & Pasley, 2004).

Teachers that understand the importance of communication in the understanding of mathematical concepts employ instructional strategies that allow students to explain their problems and solutions in mathematical terms to the teacher and to other students (NCTM, 2000). In a study that interviewed 400 students from inner-city, low-income middle and high schools over a three year period in Philadelphia, students recognized the teacher as the main determinant in how much was learned in the class. Throughout the study, students identified “good” teachers as those individuals that pushed all students to achieve within the class. Interaction between the teacher and the students was positive.
and students were offered continuous encouragement regardless of academic ability (Corbett & Wilson, 2002). In order for effective mathematics communication to occur, students need support from the teacher and the teacher needs to create a learning environment in which the students feel safe enough to take risks. Based on research conducted in 10 Boston high schools, discussions with 150 students revealed students feel more interactive teaching styles and tasks are more culturally relevant components of school reform that encourage learning for all students (Noguera, 2004). In her book, The Dreamkeepers, Ladson-Billings (1994) utilized classroom observations and teacher interviews to examine the instructional practices and teacher characteristics of eight teachers in urban school settings. The teachers in Ladson-Billings study were educating students in schools with a large number of students receiving free and reduced lunch. The student population in these academically successful schools consisted of mostly African American and Hispanic students. These classrooms of academically successful students were learning environments in which the teacher had high expectations for all students, utilized cooperative groups, incorporated activities that related personal experiences to mathematical concepts, allowed open discussion among students in the problem solving process, and provided all students with extensive feedback for their responses to high level questions (Ladson-Billings, 1994).

Ladson-Billings findings are supported by Members of the Minority Student Achievement Network, which surveyed 41,000 middle and high school students in the 15 school districts. The survey revealed that impersonal learning environments, low teacher expectations, and instructional practices that did not create a learning environment that encouraged the active participation of all students in meaningful tasks contributed to poor
student performance in the classroom (Alson, 2002). When instruction includes activities that allow students to develop their cognitive skills and processes while actively engaging in classroom discussions, tasks, and solutions there is a positive impact on student achievement (McCaffrey, et al., 2001). Classroom environments that demonstrate balanced teacher to student interactions are in alignment with NCTM.

**Connections**

Though mathematics is often seen as an entity separate from other subject areas, reform measures in mathematics education emphasize the importance of linking new mathematical concepts to previous concepts in mathematics as well as other subject areas. According to NCTM (2000), mathematics should be viewed as a whole instead of parts. Previous mathematics course information and concepts should be linked to the concepts presented in the current mathematics course. Also, different areas of mathematics are linked to other subjects and real world situations. For example, mathematics concepts learned at the elementary level are important to understanding mathematics concepts at the middle school and high school level. Additionally, algebra concepts are linked to the concepts presented in science and geometry. Students need to experience mathematics in real world situations in order to understand the connection mathematics has to their lives outside of the classroom. Classroom instruction which employs this process standard recognizes the value of mathematics in personal and societal issues. Concepts and problems presented in class engage real world situations that can be applied to science, commerce, and social science concepts (NCTM, 2000).

Learning occurs when students engage in tasks that build on prior student experiences and knowledge while connecting with the current concepts presented.
(Boykin, 2000). Data collected on tenth grade students in the 1997-1998 school year revealed that in classrooms where teachers made connections between previous concepts and new concepts, students performed better on the multiple choice and open-ended sections of the Stanford achievement tests. In addition, students participating in integrated courses where content standards are not isolated to a single content area outperformed students participating in traditional algebra and geometry classes even when NCTM process standards and single content standards were applied (McCaffrey, et al., 2001).

**Representation**

The fifth process standard, representation, refers to the students’ ability to communicate mathematical approaches, arguments, understandings, and proofs to others, including their teacher and their classmates. Students are given the opportunity to apply mathematics concepts to realistic problems and to explain their solutions through diagrams, graphical displays, and symbolic expression. Representations should be conventional and non-convention and classroom instruction should integrate technology as a viable tool in addressing this process standard (NCTM, 2000). Representing ideas using symbols and expressions should be introduced in the earliest stages of mathematics instruction through a context that even the youngest students can relate (Lubinski & Otto, 2004). Lubinski and Otto (2004) videotaped and transcribed a lesson taught in a first grade classroom that emphasized the process standard, representation. Through teacher questioning and student centered discussions, students were able to explain “what each number and each arithmetic expression represented to give them practice in communicating their understanding of the representation.” Representations in this lesson
were models of a physical situation found in the literature that was used by the teacher to present first grade mathematics concepts in addition. The transcribed discussion revealed that the students were beginning to understand that equations were representations of a situation and not just something to be solved. Thus, the lesson served as the beginning steps to algebraic reasoning as well (Lubinski & Otto, 2004).

Success in mathematics relies heavily upon a student’s ability to understand the mathematical concepts being taught and actively build new knowledge upon prior knowledge through experience (NCTM, 2000; Boykin, 2000; Boykin, 2003). Students that are successful in mathematics engage in numerous meaningful tasks that allow the students a degree of flexibility to choose from a variety of computational strategies and explain their methods orally or in writing to support the accuracy of their answers. Diagrams, graphs, and tables are used to represent the student’s findings. In a study of 384 students at the eighth grade level in 12 eighth grade classes, the impact of cooperative learning and meta-cognitive training on student achievement was examined. Meta-cognitive training relates to the NCTM standards of problem solving, reasoning and proof, connections, communication, and representation (NCTM, 2000). Students who engaged in problem solving activities with cooperative learning and meta-cognitive training outperformed other student groups on graph interpretation and various mathematical explanations (Kramarski & Mevarech, 2003).

Technology is essential in the teaching and learning process of mathematics (NCTM, 2000), particularly in regard to representation. Since computers and the technology that is associated with them dominates the workforce and the lives of citizens in the United States, persons who can not understand the language of computers, which
are run by symbolic systems, are usually the same persons who have little understanding of mathematics. This limited understanding of technology, computers, and mathematics in turn limits an individual's economic opportunities (Checkley, 2001). Students need to learn mathematical concepts through the use of technological tools. Teaching with technology can allow more time for students to concentrate on additional methods for solving the same problem and allow students to freely explore a variety of problem solving techniques. The use of technological instruments, such as graphing calculators, can promote more effective teaching and learning as well as develop a more student-centered learning environment that allows the teacher to spend more time addressing individual student needs (Kutzler, 2000). The use of technology can change student attitudes toward mathematics, especially Algebra. Technological tools can motivate students and encourage improvements in a student's understanding of the mathematical concepts presented during classroom instruction (Noguera, 2001). Teachers that feel comfortable with technological tools for mathematics tend to incorporate technology into their classroom instruction and student exploration of mathematical concepts (Fogarty, Cretchley, Harman, Ellerton, & Konki, 2001). Students that utilize technology, such as computers for simulations, demonstrations, and application of concepts perform better on standardized mathematics assessments than students that are exposed to technology that merely serves as an instrument of remediation (Meborn, 2001; Berry, 2002). The use of technology is especially important to high school students entering introductory level algebra courses. In a study of 16 developmental mathematics students attending an introductory level high school algebra course, students that engaged in frequent discussions concerning the concepts presented in class and that utilized technology
regularly, better understood the mathematical concepts presented in the course (Pugalee, 2001). The data suggests that limited exposure to technology has a negative impact on mathematics achievement.

Content Standards

For the current study, the content standards of algebra at the middle school and high school levels are addressed. The standards established by the NCTM are explanations of what mathematics instruction should enable students to comprehend and perform. The purpose of such standards is to develop a society that is able to think and reason mathematically (NCTM, 2000).

There are four strands reflected throughout the algebra content standard from pre-kindergarten through twelfth grade. Student success with the tasks and skills outlined in the middle school and high school content standards rely heavily on incorporating the process standards while building upon the pre-kindergarten through fifth grade knowledge and mastery of the content standards gained through mathematical experiences at each grade level. Mastery of algebra requires a student to demonstrate an understanding of patterns, relations, and functions. Beginning in the early grades, students need to develop an in-depth understanding of a variety of numbers (whole numbers, decimals, and fractions) and the relationship between and among these numbers. Students need to look for patterns in which the focus is on recognizing regularity, similar patterns in different forms, and using patterns as a context for making predictions (Wu, 2001). By middle school and high school, students should have been exposed to numerous experiences in the classroom that enabled them to create and use tables, symbolic expressions, graphs, and words. The students should be able to
represent and examine functions and patterns of change through the exploration of real world problems that involve constant rates of change, like the extent to which an individual uses long distance minutes on his or her telephone. While the cost per minute remains the same, the time a customer uses on each long distance call changes and affects the overall price of the phone bill (NCTM, 2000). Students must compare and contrast situations modeled by functions and explain the differences present in each model. Real world situations should be incorporated to give students experience with utilizing algebraic concepts (NCTM, 2000; Schoenfeld, 2000)

Additionally, success in algebra requires a student to demonstrate an ability to represent and analyze mathematical situations and structures using algebraic symbols. Being able to represent and analyze situations using algebraic symbols assists students in solving problems in other curriculum areas. A school curriculum that links subject areas and concepts together between and within grade levels plays a key role in ensuring that academic achievement occurs among all students. Curriculum that does not offer connections results in poor academic performance in schools (Noguera, 2004; Weiss & Pasley, 2003). To fully grasp algebra, students need to understand the various roles of a variable. Variables can simply take the place of a number that can be found by solving an equation, the variable may represent a generalized arithmetic pattern, or the variable can show an example of co-variation where the value changes as the value of another variable changes. Students gradually understand the meaning and uses of variables as they are given ample opportunities to explore variables through their creations of and use of variables in tables, graphs, and discussions (NCTM, 2000).
Also, throughout their mathematical experiences, students need to exhibit an understanding of how to use mathematical models to represent and understand quantitative relationships. Students should be given opportunities for exposure to situations and relationships involving linear and non-linear functions. Problems that involve trends in data sets as well as problems that deal with compound-interest allow students the opportunity to use computers and graphing calculators to produce graphs and perform complex calculations that enable students to explain patterns of quantitative change (NCTM, 2000). In the state of Virginia, teachers are required to incorporate graphing calculators into the Algebra I and Algebra II courses (Commonwealth of Virginia, 2001 cited in Mick, 2003). The standards of learning assessments (SOLs) for Algebra I, Geometry, and Algebra II allow graphing calculators to be used on these state assessments. Clearly, opportunities for the use of technology have been recognized as an important component of the algebra curriculum for the state of Virginia. While investigating the importance of TI-83 graphing calculators and their use in the classrooms of rural Virginia participating in the Local System Change grant, Mick (2003) found that the use of TI-83 calculators were a valuable strategy to use in solving one-variable equations and converting one-variable equations to functional form. Through this investigation, Mick (2003) concluded that while access to technology tools such as the TI-83 graphing calculator is important to achievement in algebra, he cautioned against the use of technology without a solid foundation built upon previous concepts linked to the new concepts. Similar to NCTM, Mick encouraged a balance between technology and other methods of instructional delivery and content exploration for success in algebra (Mick, 2003).
Finally, students participating in algebra instruction must be able to show how to analyze change in various contexts (NCTM, 2000; Joyner & Reys, 2001). Students must be exposed to situations in which the quantities of the variables change. Different graphs and tables are used to represent different relationships present in the same situation. The ability to be able to understand the different relationships present in similar situations is the conceptual building block for the mathematical concepts presented in calculus (NCTM, 2000). The use of a variety of activities to address the same concepts proved successful in the nationally recognized Thomas Jefferson High School for Science and Technology where the teachers utilize hands-on activities, computer labs, and cooperative learning groups along with dialogue between the teacher and students to enhance learning in the classroom environment (Dove & Keiler, 2004).

Success in algebra must involve a union of content and process standards which are a part of a standards-based curriculum in pre-kindergarten through grade twelve. The process standards are the avenue through which students obtain and utilize content knowledge in algebra and the other math content areas (NCTM, 2000). In a research study of the nationally ranked Thomas Jefferson High School for Science and Technology, researchers found that instructors in algebra, geometry, trigonometry, and pre-calculus classes encouraged students to utilize instructional delivery and assessment methods closely aligned with NCTM content and process standards. This successful high school, which was formerly characterized as low achieving, employed reform strategies based on the QUASAR project and IMP (Interactive Mathematics Program) to raise student achievement throughout the school, and across subjects and grade levels (Dove & Keiler, 2004). Students were observed giving verbal explanations for homework.
problems. The verbal explanations were used by the instructors to assess understanding of the material. When questions remained, the teachers provided follow up through demonstration. Lectures to introduce new concepts were conducted for brief periods and then students explored their understanding of the concepts in small group activities that included matching functions and graphs through cards, computer lab assignments, and experiments with graphing calculators. Visual representations and hands-on experiments addressed the diverse learning styles of the students. Continuous questioning, presentations based on real world situations and the prior knowledge of students along with a classroom learning environment that encourages students to make connections between previous concepts and new concepts were noted by researchers as having a positive impact on the academic achievement of the students in the mathematics classes observed (Dove & Keiler, 2004).

**Algebra as a Necessity**

Mathematics is stressed as the key to opportunity. Within the array of mathematic subjects available to students, it is algebra that is considered the "gatekeeper course" and a "civil rights issue" (Moses & Cobb, 2001). During the study of reform methods in ten Boston high schools, a review of student records revealed that more than 50 percent of the 150 member sample group of students that failed the math portion of the Massachusetts Assessment System (MAS) exam performed poorly in Algebra I and had not enrolled in any other higher-level mathematics courses. An examination of the mathematics section of the MAS exam revealed that successful completion of Algebra I, Geometry, and Algebra II are needed in order to pass the MAS mathematics exam (Noguera, 2004). The successful completion of algebra enables a student to enter into the
advanced mathematics courses offered at the secondary school level, college courses, and employment in technical fields. Studies suggest that students lack an adequate understanding of the most basic algebraic concepts and thus avoid attending algebra courses. Therefore, these students remove themselves from the possibility of entering more advanced mathematics courses that will lead to future educational and professional opportunities (Carter, Ferrucci, & Yeap, 2002).

The structure of public schools causes differential access to algebra that Moses and Cobb (1999) equate to a structural form of discrimination, which excludes African Americans from the possibility of financial attainment that other students can gain through a public school education in the United States. The lack of access to algebra caused civil rights activist Robert Moses to begin the Algebra Project in Cambridge, Massachusetts during the 1980's. The Algebra Project is a transitions curriculum that encourages students to create pictorial representations based on experiences with physical events introduced by the instructor. The students describe the events and pictures in their own words first and then are guided to describe the information using mathematical terms. The students are guided by the teacher toward an understanding of algebra through culturally relevant experiences. Moses stresses the need for instructors to arrive in the mathematics classroom ready to meet students where they stand and work toward an understanding of the foreign symbolic terrain presented in traditional algebra textbooks (Hall, 2002). Currently, there are 13 states in rural, suburban, and urban areas utilizing the Algebra Project transitions curriculum to reach more than 40,000 students. A comparison of data collected before and after the implementation of the Algebra Project has shown that students have scored higher on state mandated tests of algebra.
proficiency after each year of the program’s adoption. In Bessemer, Alabama, students of the Algebra Project curriculum with lower socioeconomic status performed better on state mandated assessments than their high socioeconomic status peers that did not use the Algebra Project curriculum (Cazden et al., 1995; Davis & West, 2000; West, Davis, Lynch, & Atlas, 1998 cited in Hall, 2002). Moses stresses that students, teachers, and the community must demand access to instruction that will enable every student to develop an understanding of Algebra in order to preserve the civil rights of every student (Moses, 1994).

Data gathered from the National Educational Longitudinal Study found that 83 percent of the students that completed Algebra I and geometry went to college within two years of their high school graduation. Students that completed algebra in middle school were at a better advantage for academic success in advanced mathematics and science courses in high school. About sixty percent of the students that completed calculus by the end of their high school career had taken algebra in middle school. However, only 25 percent of the middle school students in the United States complete algebra by eighth grade (author, 1997).

Without the skills obtained through mathematical literacy, students from economically disadvantaged areas and poor academic backgrounds will continue to be a part of the path that leads them to continue as a member of the “economic underclass”. Higher order thinking skills and problem-solving skills associated with algebra are needed for entry into the economic mainstream (Moses & Cobb, 2001; Moses, 1994). Algebra benefits all students regardless of academic ability according to national survey data examining the impact of high school algebra on students entering high school with
varying mathematical skills. The regression analysis of assessment data for over 12,500 students indicated that participating in algebra instruction benefited all students regardless of their previous academic achievement in mathematics. An analysis of the data suggests that students opting not to take algebra upon entry into high school would have performed better in future mathematics courses if algebra had been taken (Gamoran & Hannigan, 2000). The data suggest that students are missing opportunities for access to advanced mathematics courses due to late entry into Algebra I courses.

Quality Mathematics Instructors

The need for highly qualified teachers in the field of mathematics is evident, yet the distribution of teachers remains skewed. The need for highly qualified instructors in urban schools with a significant number of minority and poor children remains (Haycock, 2003). In 1996, the National Assessment of Educational Progress (NAEP) collected data on teacher instructional practices and found that African American students were not being readily exposed to the instructional practices and strategies recommended by the NCTM. African Americans were less likely to participate in activities that stressed reasoning and non-routine problem solving skills. In addition, the use of technology was limited to remediation and drill rather than simulations, demonstrations, or applications (Berry, 2002).

Studies conducted in Lexington, Massachusetts, Philadelphia, and Pittsburgh revealed that students exposed to standards-based instruction and curriculum scored significantly higher on standardized tests in mathematics. Also, schools that strongly implemented such standards found that African American and Caucasian students outscored their peers in schools that weakly implemented these standards. Thus, students
in our diverse school populations may significantly benefit from the standards and principles set forth by the National Council of Teachers of Mathematics (Berry, 2002).

**Summary and Questions**

The literature review has addressed a number of studies that have examined the effectiveness of traditional teacher preparation programs and alternative teacher preparation programs in the development of quality teachers. Research findings suggest that both traditional teacher preparation programs and alternative teacher preparation programs provide the field of education with quality teachers as long as the following components are a part of the program: coursework in pedagogy and content knowledge, field based experiences, continuous professional development, and access to a mentor. In addition, the literature review examined research that supports the use of NCTM standards as a means to encourage student achievement in mathematics. There are a number of studies that have examined a variety of alternative teacher preparation programs and their impact on teacher preparedness, student achievement in a variety of subject areas, and the frequency of the use of effective instructional strategies for diverse student populations.

However, the literature lacks research comparing traditional teacher preparation programs to an alternative teacher preparation program in relation to student achievement, instructional strategies used in Algebra I classrooms, and the understanding educators demonstrate through classroom practices in regard to the principles and standards set forth by the NCTM. A review of the literature did not provide research findings from studies that examined the impact of teacher preparation on student achievement, the implementation of the process standards set forth by the NCTM, and the
NCTM standards that are linked to student achievement in the algebra classroom. This study contributes to the current body of knowledge concerned with teacher preparation programs, instructional strategies linked to NCTM standards, and student achievement in algebra at the middle school and high school levels. In the present study, NCTM standards were used to examine the research questions: Does teacher training impact the academic achievement of students in mathematics? How does teacher preparation impact the implementation of the process standards set forth by the NCTM? Does the frequency with which teachers use process and content standards influence student achievement?
Chapter Three: Method

Overview and Design

Through the utilization of a mixed methods comparative design, the impact of traditional and alternative teacher preparation programs on the instructional delivery methods and assessment tools used in middle school and high school level Algebra classrooms in urban public schools was explored. An observational tool designed using blueprints aligned with the process standards for grades six through twelve, the content standards for algebra, and the principles of the National Council of Teachers of Mathematics (NCTM) were used to explore the impact of teacher preparation on the instructional delivery methods and assessment tools used within the Algebra classroom. A teacher questionnaire designed with blueprints also aligned with the process and algebra content standards for grades six through 12 and the principles of the NCTM explored the instructional delivery methods and assessment tools that educators utilize to promote academic achievement among their students. District level quarterly assessments and the state mandated Virginia Standards of Learning end of year assessment was used to explore the influence of teacher training programs on student achievement, mathematics instruction, and the use of the process standards set forth by the NCTM.

The alternative teacher preparation program referred to in this study is the Transition to Teaching program. This alternative teacher preparation program provides training to individuals interested in entering the field of teaching, but who have not received degrees in education. In order for interested persons to receive consideration for this program, the potential participant must have a 2.5 grade point average or higher in all college coursework, a bachelor’s degree or higher from an accredited college or
university with courses in English, mathematics, social studies, and science or a bachelor's degree or higher from an accredited college or university with work experience related to English, mathematics, social studies, and/or science, a qualifying score on the Praxis I series of tests that meets the licensure requirements of Virginia in the area of reading, writing, and mathematics, and a qualifying score on the Praxis II content test with qualifying scores for a Virginia teaching license. In addition, persons interested in the program must meet the requirements for employment as a public school educator in Virginia (Transition to Teaching, 2004).

The Transition to Teaching program requires qualified candidates to participate in a four week Summer Institute that focuses on education coursework. Program participants are expected to obtain a Virginia Professional License with an endorsement in secondary content areas, such as secondary English, mathematics, social studies, or science. Each participant is expected to commit to teach for three years in the urban school district where they received their training (Transition to Teaching, 2004).

**Schools and Participants**

Nine middle schools and five high schools in this urban public school system were considered for this study. The selection of the schools for participation in the study was based on the availability of Algebra I classes within the school system in which the instructor is classified as a first year teacher. The student population of the schools was equally balanced in regard to race/ethnicity and gender according to the enrollment data provided as of September 30, 2003.

Teacher selection for the classroom observations and questionnaires was based on the availability of the teachers trained in the alternative preparation program, Transition
to Teaching, that were instructing students in Algebra I at the middle school or high school level. This cohort of alternatively trained new teachers was matched with a group of first year Algebra I teachers at the middle school and high school levels that were trained in a traditional teacher preparation program. The participants were matched on the level of instruction, which is middle school level or high school level, Algebra I class instruction, and the length of the class session. It should be noted that the structure of the middle school level Algebra I class differs from the structure of the high school level Algebra I class. The teachers at the high school level taught Algebra I in a block scheduling format of 2 hours per class session while the instructors at the middle school level taught in a traditional scheduling format of 60 minutes per class session. The participants were given informed consent forms outlining their rights as study participants as well as the goals and expectations of their participation in the study. The cohort of teachers trained in an alternative preparation program consisted of four teachers at the high school level and two teachers at the middle school level. There were four females and two males in the alternatively trained cohort. The comparison group of new teachers consisted of four teachers at the high school level and two teachers at the middle school level teaching Algebra I courses. There were two males and four females in this comparison group.

Instrumentation

Classroom Observation Tool

A classroom observational tool was used for classroom observations (see Appendix A). The observational tool measured the instructional practices, assessment tools, student- to- student interactions, and teacher- to student interactions that occurred
during each observed class session. The alignment of the observation tool with the standards and principles of the National Council for Teachers of Mathematics (NCTM) was examined through the use of blueprints. The categories listed on the blueprints are the process standards (Appendix D), algebra content standards (Appendix C), and principles (Appendix B) established by the NCTM. The process standards for mathematics are: problem solving, reasoning and proof, communication, connections, and representation. In addition to the process standards, the blueprint categorized the items on the observational tool by the content standards for algebra as designated by NCTM (NCTM, 2000). The four algebra content standards are as follows: demonstrate an understanding of patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; and analyze change in various contexts (NCTM, 2000). Finally, the blueprint was utilized to align the classroom observational tool with the six principles. The six principles are as follows: equity, curriculum, teaching, learning, assessment, and technology. The process standards, algebra contents standards, and principles are intertwined with one another to create a classroom environment that promotes student understanding of mathematical concepts. Each observational tool item was categorized based on the standard and/or principle that the item addressed. The classroom observational tool included a qualitative component which allowed the observers to describe the activities taking place during the observation. These descriptions were used in the descriptive analysis of the data found in Chapter 4.

An expert panel of mathematics teachers with experience in writing mathematics curriculum aligned with state mandated assessments and NCTM guidelines examined the
classroom observational tool prior to its use in the classroom. Two university researchers with expertise in classroom observations utilized the instrument within classroom observations for a mathematics classroom. A Pearson product-moment correlation (r) was used to determine the reliability of the instrument based on the responses of the expert panel of mathematics teachers and university researchers. The Pearson r yielded a +.87 correlation. The reliability of the classroom observational tool was further calculated through exact matching using inter-rater reliability. The inter-rater reliability examined the frequency at which the two university observers gave the same rating for each item as observations were conducted in the same classroom environment. The university researchers agreed 67 percent of the time for each item on the observational tool.

**Teacher Questionnaire**

A teacher questionnaire (Appendix E) with a frequency of use scale was developed to measure the level of awareness participants have in regard to NCTM standards, instructional strategies and assessment tools related to NCTM standards and principles, and the impact these standards, principles, strategies, and tools have on student achievement. The teacher questionnaire was aligned with the standards and principles of the NCTM through the use of blueprints. The first blueprint categorized the items on the questionnaire by the content standards for algebra (Appendix G). The second blueprint categorized the questionnaire items by the process standards (Appendix H). The final blueprint (Appendix F) categorized the questionnaire items by the NCTM principles that are intertwined with the process and content standards that students need to acquire in order to use the mathematical knowledge gained from algebra instruction.
The teacher questionnaire consists of twenty-four items. Two of the questionnaire items are related to the participant's general understanding of the standards and principles set forth by the NCTM. Two of the items are specifically related to content standards for Algebra. Four of the items pertain to teacher preparation in relation to the principles of teaching and learning. The remaining sixteen items pertain to the process standards for mathematics. The questionnaire was initially reviewed by a panel of mathematics instructors with membership in the National Council of Teachers of Mathematics. The panel of experts conducted an initial review and reviewed the instrument once more to check final revisions for accuracy and clarity. Prior to being administered to the participants of the study, the questionnaire was piloted among middle school and high school Algebra I instructors that were not participating in the study. The pilot study was a way for the researcher to determine the type of results that could be expected from the responses gathered from research participants.

**Quarterly Mathematics Assessments**

The district administers a quarterly mathematics assessment to monitor the progress of Algebra students throughout the year. The quarterly assessment was designed using the Virginia Standards of Learning sample test items, a blueprint, and objectives. A panel of mathematics instructors along with the mathematics coordinator for secondary education within the school district worked collaboratively to design test items that mirrored the format and depth of items found on the state mandated Algebra I end of course assessment. The data derived from these quarterly assessments was used to determine academic growth among Algebra students in both groups of teachers. The quarterly assessments examine the students' ability to utilize algebraic symbols, solve
problems using graphs, tables, and equations, understand patterns, relations, and functions, and model and solve complex problems using a variety of problem solving strategies.

**Virginia Standards of Learning End of Year Assessment**

The state of Virginia requires all school districts to administer an end of course assessment for Algebra I courses. The Standards of Learning Assessment for Algebra I was designed by a panel of experts. This expert panel was derived from specialists in mathematics education at the Virginia State Department of Education, experienced mathematics instructors from various school districts throughout the state of Virginia, university faculty with expertise in mathematics and instruction, and members of the Virginia Council of Teachers of Mathematics, which is an affiliate of the National Council of Teachers of Mathematics. The Virginia Standards of Learning end of year assessment was aligned with the standards established by the National Council of Teachers of Mathematics (Commonwealth of Virginia Board of Education, 2002). The end of year assessment was designed to be completely aligned with the algebra objectives found in the Virginia Standards of Learning Blueprint document used by every public school district within the state (Virginia Department of Education, 2002).

A Content Review Committee consisting of Virginia educators, Virginia Department of Education personnel, and the testing contractor, Harcourt Brace Educational Measurement, worked together in 1999 to see that the items on the SOL tests matched the SOL objectives listed for the course as well as test specifications. The reliability and validity of the Algebra I end of course assessment involved correlations with other related measures and between other SOL Algebra I tests. Spearman Rank
Order Correlation coefficients between the Algebra I SOL tests and the Stanford 9 Total Math test was .53 when compared with 312 schools. The reliability and validity of the end of year assessment from the state is reviewed each year by the Virginia State Department of Education through an analysis of field tested items and student responses throughout the state. The annual review allows the Virginia State Department of Education to determine the items to revise or delete from the exam (Virginia Department of Education, 1999).

**Procedure**

Classroom observations were conducted for 30 to 45 minutes each session. The researcher and four university faculty observers utilized the classroom observation tool to record classroom events. Three to four classroom observations were conducted during the second semester of the 2003-2004 school year for each teacher participating in the study. All observations were completed prior to the administration of the Standards of Learning assessments administered by the state.

The teacher questionnaire was administered to the participants of the study in May 2004 after the classroom observations were completed. The questionnaires were colored coded to indicate the grade level and the type of teacher preparation program associated with each respondent. The questionnaires were matched across classroom observations.

The quarterly assessments were administered at the end of each quarter. The quarterly assessments were in a multiple choice format and were scored at the building level. The individual scores of the students were matched using student numbers for each individual student on every quarterly assessment. The progress of the students from
quarter to quarter were examined for the Transition to Teaching teachers and the students in the classes of the cohort teachers, which were trained in a traditional teacher preparation program.

The Virginia Standards of Learning assessments were administered in May 2004. The students' scores for this assessment were scored at the state level and the results of the assessment were reported to the individual schools in June. The scores were automatically categorized by instructor and student numbers were used for individual student scores. The student numbers on the district quarterly tests were matched with the student numbers used for the Virginia Standards of Learning assessments.
Chapter Four: Results

Overview

The impact of teacher training programs on the academic achievement of students and the use of NCTM standards and principles in Algebra I classrooms at the middle school and high school levels was evaluated through this study. Classroom observations, a teacher questionnaire, Standards of Learning assessments, and district quarterly tests were utilized to examine the research questions. Six alternatively trained teachers and six traditionally trained teachers participated in the study.

Findings

Teacher Training and Student Achievement in Mathematics

The first research question addressed by the study is: Does teacher training impact the academic achievement of students in mathematics? An analysis of variance (ANOVA) was used to compare student assessment scores to the type of teacher training the educators of these students received. The results of the ANOVA with the overall Standards of Learning (SOL) assessment scores of the students as the dependent variable and the type of teacher training as the independent variable did not reveal an effect on the achievement of students as a function of the type of teacher training at the .05 level of significance ($F = 1.172, p<.280$; see Table 1). While the inferential statistics did not reveal significance between the type of teacher training and overall student achievement, a comparison of the mean scores for the overall end of year SOL scores in Algebra I revealed a slightly higher mean score for students in the classrooms of alternatively trained teachers ($M = 450.01, SD = 39.088$; see Table 2) than the mean score for students...
in the classrooms of traditionally trained teachers ($M = 444.35$, $SD = 47.063$; see Table 2).

**Table 1**

Analysis of Variance (ANOVA) for the Standards of Learning (SOL) End of Year Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$F$</th>
<th>$\eta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers</td>
<td>1</td>
<td>1.172</td>
<td>.003</td>
<td>.280</td>
</tr>
</tbody>
</table>

**Table 2**

Descriptive Statistics for Teacher Preparation and SOL End of Year Assessment

<table>
<thead>
<tr>
<th>SOL SubCat</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>T2T Teachers</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>152</td>
<td>36.48</td>
<td>6.070</td>
<td>194</td>
<td>36.52</td>
<td>6.745</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>152</td>
<td>36.94</td>
<td>6.270</td>
<td>194</td>
<td>35.77</td>
<td>6.716</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>152</td>
<td>37.01</td>
<td>6.396</td>
<td>194</td>
<td>36.24</td>
<td>7.781</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>152</td>
<td>37.47</td>
<td>8.108</td>
<td>194</td>
<td>35.68</td>
<td>7.885</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>152</td>
<td>450.01</td>
<td>39.088</td>
<td>194</td>
<td>444.35</td>
<td>47.063</td>
<td></td>
</tr>
</tbody>
</table>

Although there were no significant differences revealed between groups on the overall SOL scores, further analyses examined whether differences existed between any of the sub-category scores and the type of teacher training received. A multivariate analysis of variance (MANOVA) with the sub-category scores on the end of year assessment as the dependent variables and the type of teacher training as the independent variable was used to determine whether there were significant differences between the achievement of students in the alternatively trained participant classrooms and the...
traditionally trained participant classrooms. Results from the MANOVA revealed significant difference in only one sub-category: statistics ($F = 4.300, p < .039$; see Table 3). These findings suggest that teacher training has a significant impact on the understanding students have in the area of statistics, as it relates to Algebra I. Based on the results of the MANOVA, the type of teacher training has no impact on student performance in regard to the SOL sub-categories of expressions and operations, relations and functions, and equations and inequalities. However, it should be noted that while there is a significant difference for the statistics sub-category between the performance of students in alternatively trained teacher classrooms and students in the traditionally trained teacher classrooms at the .05 level, the impact of the type of teacher training on student achievement in the sub-category of statistics has a small effect size ($\eta^2 = .012$; see Table 3). The small effect size suggests the type of teaching training has some, albeit a small, impact on the difference in student performance on one category of the SOL assessment: statistics.

Table 3

Multivariate Analysis of Variance (MANOVA) for the subcategories of the SOL End of Year Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>$df$</th>
<th>$F$</th>
<th>$\eta^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOL Sub-Cat 1</td>
<td>1</td>
<td>.003</td>
<td>.000</td>
<td>.960</td>
</tr>
<tr>
<td>SOL Sub-Cat 2</td>
<td>1</td>
<td>2.754</td>
<td>.008</td>
<td>.098</td>
</tr>
<tr>
<td>SOL Sub-Cat 3</td>
<td>1</td>
<td>.975</td>
<td>.003</td>
<td>.324</td>
</tr>
<tr>
<td>SOL Sub-Cat 4</td>
<td>1</td>
<td>4.300</td>
<td>.012</td>
<td>.039*</td>
</tr>
</tbody>
</table>
A comparison of the mean scores for each sub-category revealed that the mean scores for students in the classrooms of the alternatively trained teachers were slightly higher in the following sub-categories: relations and functions ($M = 36.94, SD = 6.270$, see Table 2), equations and inequalities ($M = 37.01, SD = 6.396$, see Table 2) and statistics ($M = 37.47, SD = 8.108$; see Table 2). The findings suggest that students in the classrooms of the alternatively trained educators show greater strength in addressing the objectives related to relations and functions, equations and inequalities, and statistics, whereas the students in the classrooms of the traditionally trained educators show greater strength in addressing the objectives related to expressions and operations. It should be noted that the difference in the mean scores for the expressions and operations sub-category between the traditionally trained educators ($M = 36.52, SD = 6.745$; see Table 2) and the alternatively trained educators ($M = 36.48, SD = 6.070$; see Table 2) is minimal. Therefore, the degree to which both student groups process the objectives for this sub-category are similar.

To further explore the impact of the type of teacher preparation on student achievement in mathematics classrooms, district quarterly tests were also analyzed. Because the district quarterly tests were administered by the school system three times during the school year, it was possible to examine achievement over time in the different classrooms of the study. A MANOVA with the student scores on the three district quarterly assessments as the dependent variables and the type of teacher training as the independent variable was used to determine whether there were differences between the achievement of students in the alternatively trained participant classrooms and the traditionally trained participant classrooms.
Results from the MANOVA revealed significant differences for the first district quarterly test ($F = 27.077$, $p < .000$; see Table 4) and second district quarterly test ($F = 4.690$, $p < .031$; see Table 4). There was no significant difference revealed for the third district quarterly test ($F = .914$, $p < .340$, see Table 4). These findings suggest that teacher training had a significant impact on the understanding students have for the objectives covered in Algebra I prior to the final administration of the district quarterly tests, but there was no significant impact on the understanding students have for the objectives covered in Algebra I on the final district quarterly test. However, it should be noted that while there is a significant difference between the performance of students for alternatively trained teachers and traditionally trained teachers at the .05 level on both the first and second quarterly tests, the impact of the type of teacher training on student achievement on the first district quarterly test has a greater effect size ($\eta^2 = .085$; see Table 4) than the effect size of the second district quarterly test ($\eta^2 = .016$; see Table 4). Thus, the type of teacher training did impact student performance on the first and second district quarterly tests, but not to the same degree.

### Table 4

Multivariate Analysis of Variance (MANOVA) for the District Quarterly Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>District Test 1</td>
<td>1</td>
<td>27.077</td>
<td>.085</td>
<td>.000*</td>
</tr>
<tr>
<td>District Test 2</td>
<td>1</td>
<td>4.690</td>
<td>.016</td>
<td>.031*</td>
</tr>
<tr>
<td>District Test 3</td>
<td>1</td>
<td>.914</td>
<td>.003</td>
<td>.340</td>
</tr>
</tbody>
</table>

The mean scores on the district quarterly tests revealed a level of consistency for student achievement among the alternatively trained participants. Students in the
classrooms of the traditionally trained teachers outscored students in the classrooms of the alternatively trained teachers on the first district quarterly tests, but students of the alternatively trained teachers outscored students of the traditionally trained teachers by the second district quarterly test. While there was a slight decrease in achievement between the first (M = 68.60, SD = 14.413; see Table 5) and second (M = 64.17, SD = 16.477; see Table 5) district quarterly tests, the third district quarterly test (M = 70.79, SD = 19.506; see Table 5) revealed that the students in the classrooms of the alternatively trained teachers demonstrated growth throughout the year as additional Algebra I concepts and objectives were presented in class. This continuous growth was not experienced in the classrooms of the traditionally trained teachers where mean scores reflect a decline in student performance for the second (M = 59.54, SD = 19.874; see Table 5) and third (M = 68.70, SD = 17.933; see Table 5) district quarterly tests when compared to the first (M = 77.83, SD = 14.413; see Table 5) district quarterly test.

### Table 5

<table>
<thead>
<tr>
<th>T2T Teachers</th>
<th>Traditional Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Quarterly Test 1</td>
<td>144</td>
</tr>
<tr>
<td>Quarterly Test 2</td>
<td>144</td>
</tr>
<tr>
<td>Quarterly Test 3</td>
<td>144</td>
</tr>
</tbody>
</table>

The descriptive analyses of the Standards of Learning assessment and district quarterly tests revealed a general trend for students in the classrooms of the alternatively trained teachers to perform slightly better on standardized assessments than students in the classrooms of the traditionally trained teachers. Significant differences for the statistics sub-category of the Standards of Learning assessment and the first and second
district quarterly tests suggest that the type of teacher training has some impact on student achievement in Algebra I classrooms at the high school and middle school level, but the effect sizes for these differences are small for two of the three significant findings. Also, one significant difference, the first district quarterly test, favors traditional teacher preparation.

**Teacher Training and the Use of the National Council of Teachers of Mathematics (NCTM) Standards**

The second research question addressed by the study is: How does teacher preparation impact the implementation of the process standards set forth by the NCTM? First, the frequency of use for the instructional practices that reflect the NCTM process standards in the classroom was examined through an analysis of data obtained from 42 classroom observations conducted utilizing the classroom observation tool. Second, the perception of the teachers in regard to the frequency of use for the instructional practices that reflect the NCTM process standards in the classroom was examined through a teacher questionnaire administered to the twelve study participants.

**Classroom Observation Findings**

Descriptive analyses were used to examine potential differences between teacher training and the use of NCTM standards because the small sample size of the teachers precluded the use of inferential statistics. Based on the classroom observation means for the overall use of instructional practices reflecting the five process standards, alternatively trained teachers had a greater mean ($M = 1.46, SD = 0.390$; see Table 6) for the use of these activities in their Algebra I classrooms than traditionally trained teachers ($M = 1.06, SD = 0.564$; see Table 6). These findings suggest that alternatively trained
teachers employed the five process standards throughout their classroom instruction more frequently than traditionally trained teachers.

Table 6

Descriptive Statistics for Teacher Training and the Use of NCTM Process and Algebra Standards through Classroom Observations

<table>
<thead>
<tr>
<th>Instructional practices related to the Standards</th>
<th>T2T</th>
<th></th>
<th></th>
<th>Traditional</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Assess Prior Knowledge</td>
<td>6</td>
<td>1.72</td>
<td>.557</td>
<td>6</td>
<td>1.42</td>
<td>.823</td>
</tr>
<tr>
<td>Real world situations</td>
<td>6</td>
<td>1.04</td>
<td>.596</td>
<td>6</td>
<td>.236</td>
<td>.291</td>
</tr>
<tr>
<td>Engaged all students</td>
<td>6</td>
<td>2.06</td>
<td>.400</td>
<td>6</td>
<td>1.64</td>
<td>.853</td>
</tr>
<tr>
<td>Adequate wait time</td>
<td>6</td>
<td>1.83</td>
<td>.732</td>
<td>6</td>
<td>1.43</td>
<td>.851</td>
</tr>
<tr>
<td>Follow up</td>
<td>6</td>
<td>2.00</td>
<td>.848</td>
<td>6</td>
<td>1.86</td>
<td>.854</td>
</tr>
<tr>
<td>Cooperative groups &amp; Present/prior learning</td>
<td>6</td>
<td>.833</td>
<td>.736</td>
<td>6</td>
<td>.528</td>
<td>.424</td>
</tr>
<tr>
<td>Cooperative groups &amp; Problem solving</td>
<td>6</td>
<td>.542</td>
<td>.714</td>
<td>6</td>
<td>.444</td>
<td>.356</td>
</tr>
<tr>
<td>Variety of methods</td>
<td>6</td>
<td>1.19</td>
<td>.693</td>
<td>6</td>
<td>.889</td>
<td>.911</td>
</tr>
<tr>
<td>Students generate data</td>
<td>6</td>
<td>.625</td>
<td>.711</td>
<td>6</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Use math terms</td>
<td>6</td>
<td>2.08</td>
<td>.573</td>
<td>6</td>
<td>1.71</td>
<td>1.05</td>
</tr>
<tr>
<td>Remediation/enrichment</td>
<td>6</td>
<td>2.10</td>
<td>.490</td>
<td>6</td>
<td>1.56</td>
<td>1.33</td>
</tr>
<tr>
<td>Overall process use</td>
<td>6</td>
<td>1.46</td>
<td>.390</td>
<td>6</td>
<td>1.06</td>
<td>.564</td>
</tr>
<tr>
<td>Use of spreadsheets</td>
<td>6</td>
<td>.111</td>
<td>.272</td>
<td>6</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Computer algebra system</td>
<td>6</td>
<td>.361</td>
<td>.670</td>
<td>6</td>
<td>.347</td>
<td>.523</td>
</tr>
<tr>
<td>Use of graphing utilities</td>
<td>6</td>
<td>1.40</td>
<td>.335</td>
<td>6</td>
<td>1.25</td>
<td>.707</td>
</tr>
<tr>
<td>Overall algebra use</td>
<td>6</td>
<td>.625</td>
<td>.212</td>
<td>6</td>
<td>.532</td>
<td>.380</td>
</tr>
</tbody>
</table>
In order to develop a better understanding of the frequency of use for the instructional practices related to the process standards observed in Algebra I classrooms at the middle and high school levels, the means for the observed instructional practices pertaining to individual process standards were examined. The means for eleven observable instructional practices exhibited on the classroom observation tool revealed that alternatively trained teachers had higher mean scores than traditionally trained teachers for the use of NCTM process standards in the classroom (see Table 6). The differences between the means for the alternatively trained teachers and the traditionally trained teachers was greatest for the use of real world situations ($M = 1.04$ versus $M = .236$), the opportunities for students to generate data ($M = .625$ versus $M = .000$), and the availability of remediation and enrichment activities ($M = 2.10$ versus $M = 1.56$), respectively. These findings suggest that teachers participating in the alternative teacher preparation program incorporated these instructional practices more frequently during classroom instruction than teachers participating in a traditional teacher preparation program. However, it should be noted that the difference between the means were slight between traditionally trained and alternatively trained teachers on the following instructional practices related to the NCTM process standards: adequate wait time, follow up, and cooperative groups and problem solving (see Table 6).

Qualitative descriptions of how the process standards were addressed during classroom observations were recorded by the research observers of the study. In regard to how teachers assessed prior knowledge, research observers described, “An inquiry questioning technique was used to answer questions. This questioning probed prior knowledge to help students make connections. Questions linked prior chapters to current
work and students needed previous notes to help with their responses.” In addition to basic approaches to assessing prior knowledge, one research observer noted a creative approach to addressing prior knowledge during classroom instruction. “Students demonstrated a positive slope by stretching their arms in a diagonal upward motion.”

Based on the mean scores, alternatively trained teachers ($M = 2.06$) engaged all students more frequently during classroom instruction than traditionally trained teachers ($M = 1.64$). During a classroom observation of an alternatively trained teacher, a research observer noted that, “There were 13 students in class. Ms. X asked questions or called on each student at least twice. Eight students were called on four times. She constantly circulated the classroom helping students. Her movement was also a management technique to gauge for on task behavior and to check for understanding.”

The alternatively trained educators demonstrated a greater frequency of use for these three instructional practices when compared to the traditionally trained educators: follow-up provided by teachers for student responses ($M = 2.00$ versus $M = 1.86$), the use of mathematical terms by students to explain algebra concepts ($M = 2.08$ versus $M = 1.71$), and the availability of remediation and enrichment opportunities for students individually and in group to understand and explore mathematical concepts ($M = 2.10$ versus $M = 1.56$). These were the instructional strategies with the largest mean values (see Table 6). These instructional strategies pertain to the process standards of problem solving, reasoning and proof, communication, connections, and representation.

While some differences were observed, the means for the use of instructional practices pertaining to the process standards were low for both groups when the scale of the observational tool was taken into account. The rating scale of the classroom
observational tool used for this study was a four point Likert scale with the following response options: (0) not observed at all, (1) minimally observed, (2) moderately observed, and (3) extensively observed. The overall mean scores revealed that neither the alternatively trained teachers nor the traditionally trained teachers demonstrated mean scores reflecting moderate or extensive use of the instructional practices pertaining to the process standards in their Algebra I classrooms. Individual instructional practices on which the alternatively trained teachers obtained a mean rating of moderately used (2.00 or above) did exist. Alternatively trained teachers moderately engaged all students ($M = 2.06$), provided follow up for student responses ($M = 2.00$), utilized mathematical terms ($M = 2.08$), and provided remediation and enrichment opportunities ($M = 2.10$). The findings for the remaining instructional practices of the classroom observational tool reflected minimal use or no use (see Table 6).

In regard to the use of algebra content standards, an examination of the means for the use of instructional practices related to these standards revealed a trend similar to that of the use of instructional practices related to the process standards. Alternatively trained teachers had a higher mean score for the overall use of instructional practices related to the algebra content standards ($M = 0.625, SD = 0.212$) than traditionally trained teachers ($M = 0.532, SD = 0.380$). The use of graphing utilities had the highest frequency for both the alternatively trained and the traditionally trained. Again, the mean scores, which were in the minimal use range, were low. Both alternatively trained teachers ($M = 0.361, SD = 0.670$) and traditionally trained teachers ($M = 0.347, SD = 0.523$) demonstrated little use of computer algebra systems. As for the use of spreadsheets, classroom observations did not reveal the use of this instructional practice in the classrooms of
traditionally trained teachers ($M = 0.00, SD = 0.00$) and a less than minimal use rating for the alternatively trained teachers was revealed ($M = .111, SD = 0.272$). The findings suggest that neither alternatively trained nor traditionally trained teachers frequently incorporated the algebra content standards into their classroom instruction (see Table 6).

**Teacher Questionnaire Findings**

Teacher questionnaire responses suggest that traditionally trained teachers utilized instructional practices related to the process standards more frequently in their classrooms than the alternatively trained teachers. The mean for the use of instructional practices related to the process standards based on questionnaire responses was greater among the traditionally trained teachers ($M = 4.03, SD = 0.393$) than the alternatively trained teachers ($M = 3.89, SD = 0.477$; see Table 7). The existence of this perception among the traditionally trained teachers was somewhat surprising given that the classroom observations revealed alternatively trained teachers utilized instructional practices related to the process standards of the NCTM more frequently in their classrooms than the traditionally trained teachers. The perceptions of the educators conflicted with the findings of the classroom observations.

The same trend continued on the questionnaire for the use the instructional practices related to the algebra content standards. Traditionally trained teachers reported more frequent use of the instructional practices related to the algebra content standards ($M = 3.67, SD = 0.876$) than the alternatively trained teachers ($M = 3.25, SD = 0.821$). However, classroom observation findings conflicted with the findings of the questionnaire. Further examination of the questionnaire did reveal that alternatively trained teachers reported a better overall understanding of the NCTM standards ($M = 3.92$
versus $M = 3.67$; see Table 7), particularly in the regard to the importance of NCTM standards in the classroom than traditionally trained teachers ($M = 4.50$ versus $M = 4.00$). Also, the close mean scores between the alternatively trained and the traditionally trained teachers for the questionnaire responses revealed that overall alternatively trained teachers ($M = 3.67$) and traditionally trained teachers ($M = 3.50$) felt their teacher preparation program instruction influenced their understanding of NCTM standards and principles.

Table 7

Descriptive Statistics for Teacher Questionnaire Responses

<table>
<thead>
<tr>
<th></th>
<th>T2T Teachers</th>
<th>Traditional Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Process Standard Use</td>
<td>6</td>
<td>3.89</td>
</tr>
<tr>
<td>Algebra Standard Use</td>
<td>6</td>
<td>3.25</td>
</tr>
<tr>
<td>NCTM Importance</td>
<td>6</td>
<td>4.50</td>
</tr>
<tr>
<td>Teacher Prep&amp;NCTM</td>
<td>6</td>
<td>3.67</td>
</tr>
<tr>
<td>Understanding NCTM</td>
<td>6</td>
<td>3.92</td>
</tr>
</tbody>
</table>

Process and Algebra Standards Linked to Student Achievement in Algebra I

The third research question addressed by the study is: Does the frequency with which teachers use process standards influence student achievement? The results are organized by the findings for process and algebra content standards.

Process Standards

The impact that the use of the process standards had on the achievement of students for the Standards of Learning (SOL) assessment was examined through analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) tests. A median split was computed on the overall mean observation scores on the use of the
process standards. Then the mean of process standard use for each teacher was rated as high use or low use. The overall scores on the end of year SOL assessment served as the dependent variable for the ANOVA, while the frequency of use category (high versus low) served as the independent variable. The sub-category student scores on the end of year SOL assessment served as the dependent variables for the MANOVA, while the frequency of use category (high versus low) served as the independent variable. The results of the ANOVA revealed that the process standards had a significant impact on overall student achievement ($F = 52.829, p < .000$; see Table 8). Additionally, the MANOVA revealed that the process standards had a significant impact on student achievement for each of the four sub-categories (see Table 9). However, the direction of the findings supports the low use of the process standards for student achievement on the SOL assessment.

Table 8

Analysis of Variance (ANOVA) for Student Achievement and Process Standard Use on the SOL End of Year Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$F$</th>
<th>$\eta^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers</td>
<td>1</td>
<td>52.829</td>
<td>.133</td>
<td>.000*</td>
</tr>
</tbody>
</table>

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Table 9

Multivariate Analysis of Variance (MANOVA) for the Student Achievement and Process Standard Use on the SOL End of Year Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOL Sub-Cat 1</td>
<td>1</td>
<td>35.103</td>
<td>.093</td>
<td>.000*</td>
</tr>
<tr>
<td>SOL Sub-Cat 2</td>
<td>1</td>
<td>25.184</td>
<td>.068</td>
<td>.000*</td>
</tr>
<tr>
<td>SOL Sub-Cat 3</td>
<td>1</td>
<td>59.290</td>
<td>.147</td>
<td>.000*</td>
</tr>
<tr>
<td>SOL Sub-Cat 4</td>
<td>1</td>
<td>23.572</td>
<td>.064</td>
<td>.000*</td>
</tr>
</tbody>
</table>

The impact that the use of the process standards had on the achievement of students for the third district quarterly tests was examined through an analysis of variance (ANOVA) test. A median split was computed on the overall mean observation score for the frequency with which teachers were observed using the process standards. Again, the mean of process standard use for each teacher was categorized as high use or low use. The student scores for third district quarterly tests served as the dependent variable for the ANOVA while the frequency of use category served as the independent variable. Like the analysis conducted for the Standards of Learning assessment, the results of the ANOVA revealed that the use of the process standards has a significant impact on student achievement ($F = 29.746, p< .082$; see Table 10). The results indicated that students scored significantly higher on the district assessment when their teachers were categorized as low observed use of NCTM process standards during classroom observations. The mean of third district quarterly assessment scores for students in the classrooms of teachers rated as low use ($M = 73.51, SD = 19.008$; see Table 11) for the process standards was greater than the mean of district quarterly assessment scores for
students in the classrooms of teachers rated as high ($M = 62.78, SD = 16.628$) use for the process standards.

Table 10
Analysis of Variance (ANOVA) for the 3rd District Quarterly Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Use</td>
<td>1</td>
<td>29.746</td>
<td>0.082</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 11
Descriptive Statistics for NCTM Standard Use and the District Quarterly Assessments

<table>
<thead>
<tr>
<th></th>
<th>Low Use Teachers</th>
<th>High Use Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Quarterly Test1</td>
<td>155</td>
<td>79.94</td>
</tr>
<tr>
<td>Quarterly Test2</td>
<td>156</td>
<td>69.61</td>
</tr>
<tr>
<td>Quarterly Test3</td>
<td>185</td>
<td>73.51</td>
</tr>
</tbody>
</table>

Content Standards

The second part of the final research question addressed by this study was whether the frequency with which teachers used algebra content standards influence student achievement? ANOVA and MANOVA tests were conducted to examine whether there was a significant impact on student achievement in regard to the use of the algebra content standards and student achievement on the SOL end of year assessment. The independent variable in this analysis was whether the teacher was rated as “high” or “low” in his or her use of the algebra content standards based on the median split computed on the overall mean observation scores. The dependent variables were the
overall and the four sub-category scores of the end of year SOL assessment. Just as the findings suggested for the use of the process standards, the results of the ANOVA revealed that the use of the algebra standards had a significant impact on student achievement for the Standards of Learning assessment \( (F = 18.627, p < 0.051) \) overall. Additionally, the results of the MANOVA revealed that the use of the algebra standards had a significant impact on student achievement for all four SOL sub-categories (see Table 13).

**Table 12**

Analysis of Variance (ANOVA) for the Overall SOL Assessment and Content Standard Use

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>( F )</th>
<th>( \eta^2 )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOL Overall</td>
<td>1</td>
<td>18.627</td>
<td>0.051</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

**Table 13**

Multivariated Analysis of Variance for the Use of Algebra Standards and the Standards of Learning Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>( F )</th>
<th>( \eta^2 )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOL Sub-Cat 1</td>
<td>1</td>
<td>9.681</td>
<td>0.027</td>
<td>0.002*</td>
</tr>
<tr>
<td>SOL Sub-Cat 2</td>
<td>1</td>
<td>13.738</td>
<td>0.038</td>
<td>0.000*</td>
</tr>
<tr>
<td>SOL Sub-Cat 3</td>
<td>1</td>
<td>15.229</td>
<td>0.042</td>
<td>0.000*</td>
</tr>
<tr>
<td>SOL Sub-Cat 4</td>
<td>1</td>
<td>9.270</td>
<td>0.026</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

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The impact that the use of the content standards had on the achievement of students for the third district quarterly tests was examined through an ANOVA. A median split was computed on the overall mean observation score for the frequency with which teachers were observed using the algebra standards. Once more, the mean of algebra content standard use for each teacher was categorized as high use or low use. The student scores for third district quarterly tests served as the dependent variable for the ANOVA while the frequency of use category served as the independent variable. The results revealed that the use of the algebra content standards had an impact on student achievement ($F = 33.729, p< .091$; see Table 14).

Again, the findings supported the low use of NCTM standards. Positive academic achievement among the students was linked to the low use of the algebra content standards. However, the mean scores for the use of the algebra content standards revealed that neither the alternatively trained educators nor the traditionally trained teachers demonstrated mean scores reflecting moderate or extensive use (2.00 or higher) of the content standards in their Algebra I classrooms (see Table 6).

Table 14

Analysis of Variance (ANOVA) for the 3rd District Quarterly Assessment

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>$F$</th>
<th>$\eta$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra Use</td>
<td>1</td>
<td>33.729</td>
<td>.091</td>
<td>.000*</td>
</tr>
</tbody>
</table>
Summary

The training that teachers receive prior to their entry into the classroom may be an important contributor to student achievement. However, the results of the study are mixed. Inferential data revealed that teacher training only significantly impacted student achievement in the Standard of Learning assessment sub-category of statistics and on two of the three district quarterly tests. The first district quarterly test favored traditional teacher preparation while the second district quarterly test and the statistics sub-category of the Standard of Learning assessment favored the alternative teacher preparation program. The effect sizes of the impact were small, thus suggesting that the type of teacher training has a limited impact on student achievement. An examination of the descriptive statistics did reveal that the overall means of the alternatively trained teachers are higher for the overall SOL assessment and the third district quarterly test than the means of the traditionally trained teachers. Additionally, the data obtained through this study suggests that teachers in alternatively trained programs incorporate instructional practices related to the process and algebra content standards more readily than traditionally trained teachers. However, neither the alternatively trained nor the traditionally trained educators utilized the process and algebra content standards at a high frequency of use rate.

While the results are encouraging in regard to the success of alternative preparation programs for preparing educators to positively impact student achievement in mathematics classrooms, the data does not reveal how the frequent use of instructional practices related to the NCTM process and content standards impact student achievement in Algebra I. Though the instructional practices related to the process and content
standards did appear more frequently during observations of the alternatively trained teachers, neither the alternatively trained nor the traditionally trained teachers could be considered as extensive users of the process and content standards supported by the NCTM. Therefore, what the data does suggest is that the minimal use of the process and content standards in mathematics classrooms may have a negative impact on student achievement.
Chapter Five: Discussion

In light of No Child Left Behind (2001), an emphasis on a qualified teacher in every classroom has become a widely discussed issue and the topic of several studies. Teachers have a tremendous impact on the achievement of students throughout their academic careers. Research conducted by Sanders (1996) revealed that two students possessing equivalent achievement scores in the second grade experienced varied academic success by the fifth grade. The researcher equated the 50 percentile point difference between the two students on their fifth grade achievement tests to the difference in the teachers that each student had from second grade through fifth grade (Humphrey et al., 2002). Studies, such as the one conducted by Sanders, support the emphasis placed on the importance of teacher quality and effectiveness (Sanders & Rivers, 1996).

Interpretation and Conclusions

Impact of Teacher Preparation on Achievement

Alternative teacher preparation programs are a viable option to consider in the meeting the demands of the NCLB (2001) quality teacher requirements. Based on an analysis of the data, teacher training does impact the academic achievement of students in mathematics. An analysis of the data suggests the alternative teacher preparation program, Transition to Teaching, is a promising approach in addressing the need to supply public school classrooms with a qualified mathematics teacher. The Transition to Teaching program addressed in this study provides its participants with post graduation training, regular professional development opportunities, and continuous supervision. The teachers in the alternative teacher preparation program, Transition to Teaching,
which participated in this study, taught in the critical need area of mathematics in urban school settings with ethnically and socio-economically diverse student populations. Of the six Transition to Teaching participants, three were males. Although the results from the MANOVA revealed a significant difference in only the statistics SOL sub-category, the positive impact of alternative teacher preparation programs on student achievement is still encouraging. Descriptive statistics revealed that the mean scores for the overall SOL assessment were higher for the students in the classrooms of the alternatively trained teachers than the students in the classrooms of the traditionally trained teachers. In addition to the Standards of Learning assessment, results from the ANOVA revealed that the impact of teacher preparation is only significant for the first and second district quarterly tests. The first district quarterly test favored traditional teacher preparation programs while the second district quarterly test favored alternative teacher preparation programs. However, it should be noted that while traditionally trained teachers had higher scores on the first district quarterly test, these scores were surpassed by students in the classrooms of the alternatively trained teachers by the final administration of the district quarterly test. Though MANOVA and ANOVA findings only found a significant difference favoring alternative teacher preparation programs on two of six variables (one SOL sub-category and the second district quarterly test), these are positive findings of the study which indicate that the quality of the training received by alternatively trained teachers is at least equal to the quality of training received by traditionally trained teachers. The findings indicate that alternatively trained teachers are capable of promoting positive student achievement in their Algebra I classrooms.
Previous studies have concluded that the academic achievement of students instructed by the teachers trained in alternative teacher preparation programs did not significantly vary from the academic achievement of students instructed by teachers trained in traditional teacher preparation programs (Newman & Thomas, 1999; Miller, McKenna, & McKenna, 1998). For example, a study which matched alternatively trained teachers to traditionally trained teachers found that there was no significant difference in student performance on the Iowa Test of Basic Skills, a standardized assessment, in reading and mathematics that could be attributed to the type of teacher training the teachers of these students received (Miller, McKenna, & McKenna, 1998; Mayer et al., 2003). In the state of California, teachers prepared through alternative programs supported by the school systems and the universities were perceived as being just as effective and as well prepared as those teachers trained through traditional teacher preparation programs. Also, in the states of California, Texas, and New Jersey alternative teacher preparation programs have been used extensively since the mid-1980s to provide teacher licensure to new teachers entering the field. These alternative preparation programs have had a positive impact on increasing the number of teachers of color and men as well as recruiting and retaining highly qualified individuals from other professions (Feistritzer, 1999).

**Teacher Preparation and Instructional Practices**

Teacher training has an impact on the implementation of the instructional practices related to the process standards. Continued analysis of the data revealed that teachers who participated in the alternative teacher preparation program, Transition to Teaching, utilized the process standards sets forth by the National Council of Teachers of
Mathematics more frequently than traditionally trained teachers. According to the data gathered from the classroom observations, alternatively trained teachers demonstrated the use of the process standards more frequently than traditionally trained teachers. Also, the mean scores on the overall SOL assessment and the third district quarterly tests revealed higher mean scores for the alternatively trained teachers.

This descriptive data is supported by the literature, which suggests a positive relationship between the use of the process standards and student achievement on standardized assessments. Results from a research study conducted in the 1997-1998 school year with tenth grade mathematics students showed that students receiving their instruction in classrooms where the teacher allowed students to engage in cooperative learning groups that communicated their findings and representations to the teacher and other students performed better on Stanford achievement tests (McCaffrey et al., 2001). The aforementioned instructional strategies refer to the following NCTM process standards: problem solving, communication, reasoning and proof, and representations. In an analysis of two low-performing first grade students, the researcher identified instructional practices related to the process standards that contributed to the academic improvement of the students in a first grade classroom (Empson, 2003). Based on the classroom observations conducted by the researcher, the teacher provided remediation through individualized and small group intervention, follow up for incomplete or incorrect responses, and cooperative learning groups to explore problem solving strategies with minimal teacher intervention (Empson, 2003). Further supporting the positive impact of NCTM process standards on student achievement are research studies that examine the impact of implementing NCTM standards-based curriculum initiatives.
In an examination of twenty-five classrooms where teachers reported using practices consistent with NCTM process standards, students in these standards-based instruction classes performed better on mathematics assessments than students in classes where NCTM standards were not reported as being widely utilized and understood by the reporting teachers (Spillane & Zeuli, 1999). In another study, the raw scores on the Stanford Test of Academic Skills (SAT-9) revealed that students participating in the curriculum closely aligned with NCTM performed better on this standardized assessment than students that followed the previous curriculum offered by the school, which did not closely adhere to NCTM process and content standards for algebra (Turner, 2000).

**Instructional Practices and Student Achievement**

Consistent and frequent use of the instructional practices that relate to the process and content standards may positively impact student achievement in mathematics, while a limited use of the instructional practices related to the process and content standards may negatively impact student achievement in mathematics. An examination of the data concerning whether the frequency with which teachers use process and content standards influence student achievement revealed results that contradicted the literature and previous research findings. The results suggested that the high use of the process and content standards had a negative impact on student achievement. However, a closer examination of the results revealed that neither the alternatively trained nor the traditionally trained educators utilized the process and content standards at the extensive level. Therefore, the conclusion that the frequent use of the process and content standards negatively impacts student achievement in algebra cannot be justified. Classroom observations did not reveal any teachers utilizing the instructional practices
related to the process and content standards extensively throughout a class session. Therefore the final research question could not be extensively addressed by this study.

Numerous studies support the use of the NCTM process and content standards in promoting student achievement in the mathematics classroom. For example, in Philadelphia, 8th grade students that received mathematics instruction from teachers utilizing the NCTM standards-based curriculum outperformed students that received lecture style instruction and a pre-NCTM standards curriculum (Merlino & Wolff, 2001). Also, this study revealed that even the lower ability level students in the NCTM standards-based classes significantly outperformed their lower ability counterparts on school mathematics assessments and SAT-9 (Merlino & Wolff, 2001). In a study of mathematics achievement for 8th graders in three Missouri school districts, research findings revealed higher achievement among students using the NCTM standards-based curriculum for at least two years than students using other curriculum materials (Reys et al., 2003). Also, data gathered from eleven National Science Systematic Initiative program sites that completed at least one year of standards-based instructional reform supported the use of NCTM process standards (Hamilton et al., 2003). According to the data, when instructional practices were in alignment with NCTM process standards, students perform better on standardized, multiple-choice mathematics and science assessments (Hamilton et al., 2003). NCTM supports the teacher assessing prior knowledge to guide instruction, the use of cooperative learning groups to explore concepts and problem solving strategies, and the students’ use of mathematical terms to describe a situation. Research supports the effectiveness of instruction that include activities that allow students to develop their cognitive skills and processes while actively
engaging in classroom discussions, tasks, and solutions (McCaffrey, et al., 2001). Data collected on tenth grade students in the 1997-1998 school year revealed that students performed better on the multiple choice and open-ended sections of the Stanford achievement tests when their teachers made connections between previous concepts and new concepts. Additionally, the use of numerous illustrations and manipulatives to present specific concepts, and cooperative learning groups in which students communicated their findings and representations in mathematical terms suggested a positive impact on student performance (McCaffrey et al., 2001).

While the findings of this study contradict previous studies supporting the use of NCTM process and standards to promote student achievement in mathematics, an alternative explanation of the data presented in this study may be that NCTM process and content standards are not effectively aligned with the Standards of Learning assessment for algebra or the district quarterly tests that are aligned with the Standards of Learning algebra assessment. The NCTM process and content standards focus on a student’s use of higher level thinking and mathematical application skills, so there is a possibility that basic skills are more effective for achieving on the end of year SOL assessment in algebra. Additionally, previous research studies that support the use of NCTM standards may have used measures that differ from those utilized in this research study. The measures used in other research studies may have been more aligned with the NCTM standards than the measures used in this study or the measures used in other research studies were more effective in examining the impact of NCTM standards on student achievement.


Limitations

This study used a variety of data gathering methods in order to minimize limitations. The questionnaire allowed the researcher to examine the level of awareness the instructors have of the principles and standards of the National Council of Teachers of Mathematics, their instructional strategies and use of assessment tools, and understanding of the relationship between student achievement and classroom practices. The use of classroom observations was a way for the researcher to compare teacher questionnaire responses to observed classroom actions. The use of the quarterly and standardized assessments allowed the researcher to monitor academic growth among and between students in both the classes of the alternatively prepared teachers and those teachers trained in a traditional teacher preparation program. Through a mixed methods design with various data gathering approaches, the researcher addressed several of the limitations presented which would not have been addressed through the singular use of certain data gathering techniques.

While the observations were a valuable tool for recording information firsthand as it occurred in the natural setting of the classroom, the presence of the researcher may have affected student to teacher and student- to- student interactions. During an observation, the researcher may not have attended to or observed certain aspects of the classroom dynamics that may be suited to the research questions being asked. The sampling of days to conduct observations increases the likelihood of certain occurrences to be missed. In order to address this limitation, the reliability of the observation instrument was checked using a Pearson product-moment correlation (r) examining the responses of an expert panel of mathematics teachers and university researchers. In
addition to the Pearson, the frequency at which the university researchers gave the same rating for each item during the same classroom observation was enhanced through interrater reliability. The validity of the observation instrument was controlled by consulting subject matter experts at the middle school, high school, and university level during the development of the observation instrument. In addition, persons conducting classroom observations received training on the use and scoring of this instrument. Also, blueprints aligned with the process and content standards for grades six through twelve and the principles of the NCTM were used to examine the content validity of the instrument.

The questionnaire was another instrument of this study that presented certain limitations. Social desirability was one limitation of a questionnaire. The teacher may have felt the need to respond as he or she thinks the researcher expects rather than supply a true response. The researcher addressed this limitation through the use of classroom observations, which were matched to the teacher questionnaires. To address the limitations of the questionnaire, a panel of mathematics instructors with membership in the National Council of Teachers of Mathematics was consulted during its development. This panel of experts conducted an initial review during which time suggestions for revisions were made. A subsequent review was conducted by the panel of experts after the revisions were completed. The questionnaire was piloted among middle school and high school educators that were not participating in the study as an additional step in controlling internal threats to validity. Also, a review of the literature and the development of a blueprint aligned with the standards and principles of the NCTM were used in the development of the questionnaire.
Other limitations of the study included the sample size. The questionnaires and classroom observations were limited to eight high school instructors and four middle school instructors. The participants were not randomly selected, but rather selected through availability, type of teacher preparation experienced, and years of teaching experience. The comparison of the cohort group to a comparable sample group of new teachers does strengthen the study, but the small sample size limits the researcher’s findings to the members of the study. Thus, the findings of the study cannot be generalized to the entire teaching population.

Selection bias in terms of potential differences among teachers’ students is a related limitation of the study. Even though the student groups were comparable, the students may have differed. Some evidence for this limitation is based on the first district quarterly test. Significant differences favoring the traditional teacher groups suggest that the students in the classrooms of the traditionally trained teachers may have been higher achievers. Thus, significant differences later favoring alternatively trained teachers are more impressive. Also, while the alternatively trained teachers participating in the study were matched to the participating traditionally trained teachers on level of instruction, length of class sessions taught, years of teaching in the school system, and the type of mathematics class taught, the two types of teachers may have differed on factors that were not identified.

The classroom observations were another limitation of the study. This study included 42 observations conducted during the second semester of the school year. Therefore, the time of year during which the observations were conducted along with the limited number of observations conducted overall for each teacher participant was a
limitation of the study to be considered. In addition, the classroom observations were conducted by observers with a stake in the alternative teacher preparation program, Transition to Teaching. Although the observers were trained on the use of the observational tool and possessed knowledge of mathematics instruction, each observer knew about the characteristics of the teachers being observed. The observers had knowledge of which teachers were traditionally trained and which teachers were trained through the Transition to Teaching program.

**Implications for Future Research and Practice**

The collaboration between research universities and public school systems is a crucial component in conducting meaningful research which addresses teacher quality, mathematics instruction, and student achievement. This study involved disaggregated data that could only be obtained through collaborative efforts between school system officials and university researchers. The relationship developed between the university and the public school system was an important factor in not only conducting the research, but also in reporting the findings in a manner that proved beneficial to all stakeholders. Future research studies which focus on public school systems and the practices necessary to promote student achievement should seek to develop university partnerships that emphasize the importance of a positive relationship between researchers at the university level and officials in the public school system.

Research studies concerned with the impact of teacher preparation programs on student achievement in mathematics classrooms should be conducted in grades kindergarten through twelve. Future studies should include the random assignment of participants. Random assignment reduces selection bias. Future studies that include a
large sample size of alternatively trained teachers and traditionally trained teacher that are studied frequently throughout an entire school year would provide educational researchers with a better understanding of the aspects of teacher preparation programs that best prepare teachers for meeting the demands of developing student understanding for a variety of mathematical concepts. A longitudinal study could benefit both alternative and traditional teacher preparation programs when the emphasis of the studies are to find the components that need to be in place to produce teachers that positively impact mathematics achievement in the classroom for all students.

While the literature review yielded previous research regarding the positive impact of the NCTM standards on student achievement in mathematics classrooms, there is a need to further investigate how the NCTM standards affect student achievement. While this study utilized multiple-choice state and district assessments aligned with state objectives to measure student achievement, future studies should utilize a wider variety of assessment tools in addition to standardized and multiple choice assessments to monitor student progress. Teacher made tests, classroom projects, the anecdotal records of the teachers, student written explanations to problems presented in class along with the district quarterly tests and the end of year SOL assessment should be utilized. An examination of student performance on a wider range of assessment instruments should be used to help researchers determine which NCTM standards are most effective in helping students demonstrate their level of comprehension for the objectives presented in their mathematics classrooms. Additionally, a greater number of classroom observations should be conducted throughout an entire school year with observers that do not have any knowledge of which teachers are alternatively trained and which teachers are traditionally
trained. This approach would address selection bias, researcher bias, history, and maturation. These limitations were difficult to address and eliminate throughout this study.

While the sample size of teacher participants is small for this study, the findings suggest that alternative teacher preparation programs are promising options for school districts to consider in the effort to provide quality teachers for students in mathematics classrooms at the middle school and high school levels. Urban school districts experience great difficulty in retaining an experienced, certified teaching staff, especially in the area of mathematics. Urban schools with a high concentration of poverty, minority, and immigrant students have the largest number of non-certified educators (Howard, 2003). Though this study took place in mathematics classrooms at the middle school and high school level within an urban school district with a more equal distribution of poverty and minority students, the findings do provide support for the ability of alternative teacher preparation programs to provide qualified teachers that are equally as effective as traditionally trained teachers.

The verdict on how the implementation of NCTM process and content standards affect student achievement is still pending. The data gathered for this study did not identify the frequent use of the NCTM standards in any of the participants' classrooms. Therefore, future research should continue to examine the relationship between NCTM standards use and student achievement in mathematics classrooms on every academic level.
References


Newport News Public Schools and Old Dominion University Transition to Teaching Partners. (2004). *Thinking about teaching middle or high school, but don't have a teaching license?* Retrieved March 1, 2004, from http://nnschools.org.


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# Appendix A
## Classroom Observation Tool
Denelle Wallace, ODU Doctoral Student

<table>
<thead>
<tr>
<th>Focus Item</th>
<th>Not Observed throughout the class session</th>
<th>Minimally Observed throughout the class session</th>
<th>Moderately Observed throughout the class session</th>
<th>Extensively Observed throughout the class session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prior knowledge and experiences assessed through an assessment tool, questioning, and/or group discussion.</td>
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<tr>
<td>Comments:</td>
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<tr>
<td>2. Real world situations are presented to introduce, review, or reinforce mathematical concepts.</td>
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<td>Comments:</td>
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<tr>
<td>3. Responses from engaged and non-engaged students are requested.</td>
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<td>Comments:</td>
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<tr>
<td>4. Adequate wait time for responses is provided (up to 5 seconds) when necessary.</td>
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<td>Comments:</td>
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<tr>
<td>5. Follow up provided for incomplete or incorrect responses when necessary.</td>
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<td>Comments:</td>
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<td>6. Cooperative learning groups explore prior and present concepts with minimal teacher intervention.</td>
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<td>Comments:</td>
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<tr>
<td>7. Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
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<td>8. Problems presented draw on a variety of methods to arrive at a solution.</td>
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<td>Comments:</td>
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<td>9. Students are presented with situations that allow them to generate data.</td>
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<td>Comments:</td>
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<tr>
<td>10. Students describe situations to the instructor and classmates using mathematical terms.</td>
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<tr>
<td>Comments:</td>
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<tr>
<td>11. Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>Comments:</td>
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<tr>
<td>12. Students will utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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<td>Comments:</td>
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<tr>
<td>13. Students will utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>Comments:</td>
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<tr>
<td>14. Individualized and/or small group instruction provides enrichment and/or remediation opportunities.</td>
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<td>Comments:</td>
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</tbody>
</table>
School: ___________________________  Observer: ___________________________
Grade Level: _______________________  Date of Observation: ___/___/200___
Subject: ____________________________  Observation Number: _____
Time In: _____________________________  Time Out: _________________________
Description of the Activity Observed: __________________________________________

Description of the Classroom Environment Upon Entry: ____________________________

Description of the Classroom Environment During Exit: ____________________________
### Appendix B: Blueprint 1  
**Observational Tool Alignment with NCTM Principles**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Responses from engaged and non-engaged students are requested.</td>
<td>Real world situations are presented to introduce, review, or reinforce mathematical concepts.</td>
<td>Prior knowledge and experiences assessed through an assessment tool, questioning, and/or group discussion.</td>
<td>Cooperative learning groups explore prior and present concepts with minimal teacher intervention.</td>
<td>Prior knowledge and experiences assessed through an assessment tool, questioning, and/or group discussion.</td>
<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>Adequate wait time for responses is provided (up to 5 seconds) when necessary.</td>
<td>Students describe situations to the instructor and classmates using mathematical terms.</td>
<td>Real world situations are presented to introduce, review, or reinforce mathematical concepts.</td>
<td>Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
<td>Responses from engaged and non-engaged students are requested.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
</tr>
<tr>
<td>Follow up provided for incomplete or incorrect responses when necessary.</td>
<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
<td>Adequate wait time for responses is provided (up to 5 seconds) when necessary.</td>
<td>Problems presented draw on a variety of methods to arrive at a solution.</td>
<td>Follow up provided for incomplete or incorrect responses when necessary.</td>
<td>Students utilize graphing utilities to solve time-consuming problems and real world situations.</td>
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<tr>
<td>Individualized and/or small group instruction provides enrichment and/or remediation opportunities.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
<td>Follow up provided for incomplete or incorrect responses when necessary.</td>
<td>Students describe situations to the instructor and classmates using mathematical terms.</td>
<td>Students describe situations to the instructor and classmates using mathematical terms.</td>
<td>Students utilize graphing utilities to solve time-consuming problems and real world situations.</td>
</tr>
<tr>
<td>Principle 1: <strong>Equity</strong></td>
<td>Principle 2: <strong>Curriculum</strong></td>
<td>Principle 3: <strong>Teaching</strong></td>
<td>Principle 4: <strong>Learning</strong></td>
<td>Principle 5: <strong>Assessment</strong></td>
<td>Principle 6: <strong>Technology</strong></td>
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<tr>
<td>Students utilize graphing utilities to solve time-consuming problems and real world situations.</td>
<td>Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
<td>Students are presented with situations that allow them to generate data.</td>
<td>Students are presented with situations that allow them to generate data.</td>
<td>Problems presented draw on a variety of methods to arrive at a solution.</td>
<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
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<td>Individualized and/or small group instruction provides enrichment and/or remediation opportunities.</td>
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Appendix C: Blueprint 2
Observational Tool Alignment with NCTM Content Standards

<table>
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<tr>
<td>Real world situations are presented to introduce, review, or reinforce mathematical concepts.</td>
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<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
<td>Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
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<td>Problems presented draw on a variety of methods to arrive at a solution.</td>
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<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>Students will utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
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**Appendix D: Blueprint 3**

*Observational Tool Alignment with NCTM Process Standards*

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<tr>
<td>Cooperative learning groups explore prior and present concepts with minimal teacher intervention.</td>
<td>Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
<td>Responses from engaged and non-engaged students are requested.</td>
<td>Prior knowledge and experiences assessed through an assessment tool, questioning, and/or group discussion.</td>
<td>Problems presented drawn on a variety of methods to arrive at a solution.</td>
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<tr>
<td>Problems presented draw on a variety of methods to arrive at a solution.</td>
<td>Cooperative learning groups explore prior and present concepts with minimal teacher intervention.</td>
<td>Cooperative learning groups explore prior and present concepts with minimal teacher intervention.</td>
<td>Cooperative learning groups explore prior and/or present concepts through a variety of problem solving strategies.</td>
<td>Students are presented with situations that allow them to generate data.</td>
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<tr>
<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
<td>Students are presented with situations that allow them to generate data.</td>
<td>Students describe situations to the instructor and classmates using mathematical terms.</td>
<td>Students utilize spreadsheets to solve time-consuming computational problems and real world situations.</td>
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<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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</table>
Students utilize graphing utilities to solve time-consuming computational problems and real world situations.

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<tr>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
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<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
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Appendix E  
Mathematics Teacher Questionnaire  
D. Wallace, ODU Doctoral Student

Directions: Please read each statement carefully. Relate the extent to which you agree or disagree with each statement. Check one box per item.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral: Neither agree or disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I understand the importance of the standards and principles created by the National Council of Teachers of Mathematics.</td>
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<tr>
<td>2. I use a variety of instructional delivery approaches to promote student understanding of mathematical concepts.</td>
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<tr>
<td>3. I incorporate individualized and/or small group instruction to provide enrichment and/or remediation opportunities.</td>
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<tr>
<td>4. I solicit responses from engaged and non-engaged students.</td>
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<tr>
<td>5. The instructional strategies set forth by the National Council of Teachers of Mathematics play a key role in planning the instructional practices I will use in my classes.</td>
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<td>6. I was exposed to information on differentiated classroom instruction and assessment tools that best meet the needs of our student population while training to become a teacher.</td>
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<td>7. The use of multiple assessment tools to monitor the academic achievement of my students was encouraged throughout my teacher preparation program.</td>
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<tr>
<td>8. I provide wait time for responses to all my students.</td>
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<tr>
<td>9. Follow up is provided to students when incomplete or incorrect responses are given.</td>
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<td>10. The frequency at which students participate in real world problem solving, data gathering, and critical thinking activities is limited in my mathematics classroom.</td>
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<td>11. The teacher preparation program I participated in helped me understand the relationship between student achievement and the principles and standards of the National Council of Teacher of Mathematics.</td>
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<tr>
<td>12.</td>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
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<tr>
<td>13.</td>
<td>Prior knowledge and experiences are assessed through group discussion and questioning.</td>
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<tr>
<td>14.</td>
<td>I link previous concepts to new concepts.</td>
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<tr>
<td>15.</td>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts.</td>
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<td>16.</td>
<td>Students explore a variety of problem solving strategies with minimal teacher intervention.</td>
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<td>17.</td>
<td>The training I received prior to entering the classroom has strengthened my ability to provide a wide variety of instructional delivery approaches that match the learning styles of a diverse student population.</td>
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<td>18.</td>
<td>Students are presented with problems that draw on a variety of methods to arrive at a solution.</td>
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<td>19.</td>
<td>Students are presented with situations that allow them to generate data.</td>
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<td>20.</td>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>21.</td>
<td>I use a variety of assessments (portfolios, journal writing, etc.) to plan for classroom instruction based on the academic needs of the students in my mathematics class.</td>
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<tr>
<td>22.</td>
<td>The use of technology (computers, graphing calculators, etc.) in the mathematics classroom plays a key role in helping my students understand the mathematical concepts presented.</td>
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<td>23.</td>
<td>Cooperative groups participate in activities that explore a variety of mathematical concepts and solutions to a given situation.</td>
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<tr>
<td>24.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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### Appendix F: Blueprint 4

**Questionnaire Alignment with NCTM Principles**

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<tbody>
<tr>
<td>I utilize a variety of instructional delivery approaches to promote student understanding of mathematical concepts.</td>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
<td>I incorporate individualized and/or small group instruction to provide enrichment and/or remediation opportunities.</td>
<td>Cooperative groups participate in activities that explore a variety of mathematical concepts and solutions to a given situation.</td>
<td>I solicit responses from engaged and non-engaged students.</td>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
</tr>
<tr>
<td>I solicit responses from engaged and non-engaged students.</td>
<td>I link previous concepts to new concepts.</td>
<td>I utilize a variety of instructional delivery approaches to promote student understanding of mathematical concepts.</td>
<td>Students explore a variety of problem solving strategies with minimal teacher intervention.</td>
<td>I use a variety of assessments to plan for classroom instruction based on the academic needs of the students in my mathematics class.</td>
<td>The use of technology in the mathematics classroom plays a key role in helping my students understand the mathematical concepts presented.</td>
</tr>
<tr>
<td>I was exposed to information on differentiated classroom instruction and assessment tools that best meet the needs of our student population while training to become a teacher.</td>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts.</td>
<td>The instructional strategies set forth by the NCTM play a key role in planning instructional practices I will use in my classes.</td>
<td>Students are presented with problems that draw on a variety of methods to arrive at a solution.</td>
<td>Prior knowledge and experiences are assessed through group discussion and questioning.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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<tr>
<td>I provide wait time for responses to all my students.</td>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts.</td>
<td>Students explore a variety of problem solving strategies with minimal teacher intervention.</td>
<td>The use of multiple assessment tools to monitor the academic achievement of my students was encouraged throughout my teacher preparation program.</td>
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<tr>
<td>I link previous concepts to new concepts. Students are presented with problems that draw on a variety of methods to arrive at a solution.</td>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
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<tr>
<td>The training I received prior to entering the classroom has strengthened my ability to provide a wide variety of instructional delivery approaches that match the learning styles of a diverse student population.</td>
<td>Students are presented with problems that draw on a variety of methods to arrive at a solution.</td>
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Appendix G: Blueprint 5

*Questionnaire Alignment with NCTM Content Standards*

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<tr>
<td>The use of technology (computers, graphing calculators, etc.) in the mathematics classroom plays a key role in helping my students understand the mathematical concepts.</td>
<td>Students are presented with problems that draw on a variety of methods to arrive at a solution.</td>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
<td>Students utilize graphing utilities to solve time-consuming computational problems and real world situations.</td>
</tr>
<tr>
<td>Students are presented with situations that allow them to generate data.</td>
<td>The use of technology (computers, graphing calculators, etc.) in the mathematics classroom plays a key role in helping my students understand the mathematical concepts presented.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
<td>Students utilize computer algebra systems to solve time-consuming computational problems and real world situations.</td>
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## Appendix H: Blueprint 6

*Questionnaire Alignment with NCTM Process Standards*

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<tr>
<td>The frequency at which students participate in real world problem solving, data gathering, and critical thinking activities is limited in my mathematics classroom.</td>
<td>The frequency at which students participate in real world problem solving, data gathering, and critical thinking activities is limited in my mathematics classroom.</td>
<td>I use a variety of instructional delivery approaches to promote student understanding of mathematical concepts.</td>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
<td>The frequency at which students participate in real world problem solving, data gathering, and critical thinking activities is limited in my mathematics classroom.</td>
</tr>
<tr>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
<td>Cooperative learning groups in my classroom explore prior and present concepts through experiments with minimal teacher intervention.</td>
<td>I incorporate individualized and/or small group instruction to provide enrichment and/or remediation opportunities.</td>
<td>Prior knowledge and experiences are assessed through group discussion and questioning.</td>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts</td>
</tr>
<tr>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts</td>
<td>I use a variety of assessments (portfolios, journal writing, etc.) to plan for classroom instruction based on the academic needs of the students in my mathematics class.</td>
<td>I solicit responses from engaged and non-engaged students.</td>
<td>I link previous concepts to new concepts.</td>
<td>I use a variety of assessments (portfolios, journal writing, etc.) to plan for classroom instruction based on the academic needs of the students in my mathematics class.</td>
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Students explore a variety of problem solving strategies with minimal teacher intervention.

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<td>I use real world situations to introduce, review, and reinforce mathematical concepts</td>
<td>I use real world situations to introduce, review, and reinforce mathematical concepts</td>
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</tr>
<tr>
<td>I provide wait time for responses to all my students.</td>
<td>I use a variety of assessments (portfolios, journal writing, etc.) to plan for classroom instruction based on the academic needs of the students in my mathematics class.</td>
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<tr>
<td>Follow up is provided to students when incomplete or incorrect responses are given.</td>
<td>Prior knowledge and experiences are assessed through group discussion and questioning.</td>
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<td></td>
<td>I link previous concepts to new concepts.</td>
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