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The Impact of the Utilization of Connected Mathematics Project with Direct instruction on Grade 8 Mathematics MAP Scores

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by

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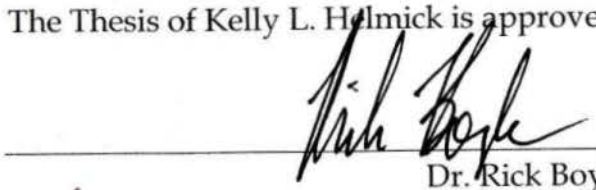

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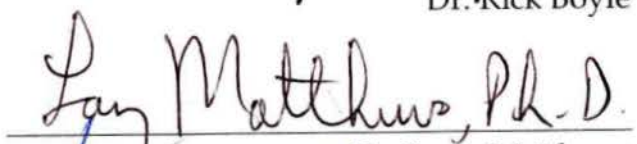

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DECLARATION OF ORIGINALITY

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work here at the Lindenwood University and that I have not submitted it for any other college or university or degree here or elsewhere.

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CHAPTER ONE

Introduction

Background of the Problem

Americans were informed by a national commission in April 1983 that they lived in a nation at risk. This risk was not due to foreign powers, weapons of mass destruction, or declining moral values. Instead, this risk was due to an erosion in the educational achievement of American students. "A Nation At Risk" pointed to the following as indicators of the problem: functionally illiterate adults, lower standardized test scores, steady decline in Scholastic Aptitude Test (SAT) scores from 1963 to 1980, increase in remedial math courses at the collegiate level, and increase in employer costs to remediate basic skills for the employees (National Commission on Excellence in Education, 1983).

In the past 20 years, many other critics of American public education have pointed to deficits in student achievement when compared to students in other countries and within subgroups of American students. Numerous initiatives have sought to decrease those gaps. Where do students stand today? Results from the 1999 Repeat of the Third International Mathematics and Science Study (TIMMS-R) indicated that eighth-grade students in Japan (579), Canada (531) and Russia (526) had higher mean scores than U. S. students (502) in math. No statistical difference was noted with England (496) while the U. S. scored higher than Italy (479). In science, eighth-grade students in Japan (550), England (538)

and Canada (533) scored higher than U. S. students (515). No statistical difference was noted with Russia (529) and again the U. S. scored higher than Italy (493) (National Center for Education Statistics, 2003).

Within the United States, gaps continue to exist between racial and socioeconomic groups. On the 2003 Communication Arts Missouri Assessment Program, 29.8% of all students scored in the proficient range. A closer examination of the disaggregated data showed that 43.7% of Asian and 33.9% of white students demonstrated proficiency while only 21.3% of Hispanics, 12.0% of blacks and 18.3% of students on free or reduced lunch reached that level. Similarly in math, 21.3% of all students were proficient. By subgroup, 42.1% of Asians and 24.4% of white students were proficient compared to 14.8% of Hispanics, 8.3% of blacks and 13.3% of students on free or reduced lunch (Department of Elementary and Secondary Education, 2003).

In response to these deficits, President George W. Bush proved that education was a top priority of his administration by sending his education reform plan to Congress during the first week following his inauguration in January of 2001. He challenged the legislature to put aside party lines and to clearly define the role of the federal government in decreasing achievement gaps for American children. President Bush's plan for educational reform included four major principles: stronger accountability for results, greater flexibility in spending federal money for states and local school districts, broader choices for parents and students, and a clearer emphasis on strategies and programs that

have proven to be successful (U.S. Department of Education, 2002). On August 1, 2001, President Bush, in a speech to the National Urban League Conference, stated, "I ask you to join me in building a system of education worthy of all America's children, so that every child has a chance in life, and not one single child, in the greatest land on the face of this Earth, is left behind" (www.whitehouse.gov/news/releases/2001/08/20010801-1.html). As a result of his leadership and the bipartisan cooperation of the members of Congress, the Elementary and Secondary Education Act of 1965 (ESEA) was reauthorized and major reforms were introduced in the No Child Left Behind Act of 2001 (NCLB) signed by President Bush on January 8, 2002.

This landmark legislation has many components designed to bring about improvement in education. States are required to develop yearly assessments in reading and math for students in grades 3-8. Schools will have annual report cards that include information from these assessments and other indicators of school quality. Federal ESEA programs were reduced from 55 to 45. Districts were given the flexibility of transferring money between federal programs. Parents of kids at failing schools have the freedom to transfer their children to more successful schools. Funding for reading increased three-fold to $900 million. Efforts to strengthen teacher quality include placing "highly- qualified teachers in every public school classroom by 2005" and allowing districts flexibility in spending a portion of their non- Title I funds for "hiring new

teachers, increasing teacher pay, improving teacher training and development of other uses" (www.ed.gov/nclb/overview/intro/factsheet.html).

As a result of the passage of NCLB, districts across the state of Missouri will be struggling to identify successful instructional strategies, curricula, and educational practices in order to improve scores on the Missouri Assessment Program (MAP). The U.S. Department of Education has approved the MAP as an instrument for assessing reading and math annually. By the spring of 2006, students in grades 3-8 will be taking these tests and districts will be striving to meet required benchmarks established by the federal government.

These efforts will be most apparent in the content area of math as the state MAP averages have ranged from 7% to 37.6% in the advanced and proficient ranges on the Grade 4, 8 and 10 mathematical tests from 1998-2003. These averages will need to increase dramatically to meet the desired 100% proficiency needed by 2014 and for districts to meet their Adequate Yearly Progress (AYP) benchmarks. According to the 2003 World Almanac and Book of Facts, 64% of eighth grade students from Missouri scored at or above the basic level in math in 1996. Sixteen states had a higher percentage than Missouri with Iowa having than highest percentage (78%). By 2000, Missouri's percentage had increased to 66%. However, twenty-two states scored as well or higher than that with Minnesota having the highest percentage (80%).

As a result of the increased scrutiny on the part of government entities at the state and federal levels, mathematical teaching methodologies and

curriculum will also be critiqued. Many theories are being considered to grapple with underachieving students. Some educators now believe that teacher-directed instruction is ineffective in developing higher-order thinking skills and that students need to use standards-based materials which develop more in-depth meaning and understanding (Trafton, 2001).

Dr. Kati Haycock identified several key points in a 2000 Briefing Book for the Missouri Legislative Forum. Students need to be in challenging curriculums that are aligned with clearly defined standards. Assessments should compare students to these standards and not to each other. Extended instruction must be provided for students who need it. Specifically referring to raising expectations in mathematics, Dr. Haycock stated that "students who complete the full college preparatory sequence perform much higher… than those who complete only one or two courses" (www.moforum.org/2000/building/student/part6.cfm).

The National Academies stated on its website that "the nation's approach to mathematics education has been inconsistent and marked by an emphasis on computation" (www4.nas.edu/onpi/webextra.nsf). Students must learn and understand the mathematical procedures that will allow them to problem solve in a various situations.

Lynn Goldsmith and June Mark point to a shift in thinking as a result of the publication of the Standards developed by the National Council of Teachers of Mathematics beginning in 1989. Advocating a standards-based approach, they see a need for students to develop conceptual understanding and reasoning

through active engagement. As they evaluated a variety of standards-based curricula, they stressed the following five themes: problem solving, reasoning and proof, communication, connections, and representation (Goldsmith and Mark, 1999).

This project will examine direct instruction and standards-based curricula and their impact on the Grade 8 Mathematics portion of the MAP. Specifically, districts in the state of Missouri that use the textbook series Connected Mathematics Project (CMP) published by Prentice-Hall will be surveyed as to the types of teaching strategies used by their teachers. The utilization of direct instruction by teachers will be compared against those who do not use direct instruction on the basis of the scores received by their students on the MAP.

Statement of the Problem

Missouri school districts are under pressure from state and federal levels to increase their MAP scores. Facing this challenge, many districts will rush into curriculum changes in the hopes of finding the magic wand that will produce desired results. Publishers will provide research that shows their material improves test scores. Do the materials truly produce this desired effect? This project will focus on one standards-based curriculum and investigate whether the districts using it combined with direct instruction score significantly higher than districts using it without direct instruction on the Grade 8 Mathematics MAP test.

Independent Variable

The independent variable in this study is the use of Connected Mathematics Project in combination with using a direct instruction approach in the classroom.

Dependent Variable

The dependent variable in this study is the performance of eighth grade students on Mathematics MAP test.

Hypothesis

Districts using the Connected Mathematics Project textbook series for middle school mathematics and using direct instruction in the classroom will realize a significant increase in their Grade 8 Mathematics MAP scores as compared to previous scores in math on the MAP without the use of the Connected Mathematics Project textbook series.

Research Question

Do Missouri school districts that use the standards-based Connected Mathematics Project textbook series at the middle school level in combination with direct instruction have higher Grade 8 Mathematics MAP scores?

Purpose of the Study

Due to the increased pressure of accountability, some school districts across Missouri are rushing into curriculum changes. While many educators agree that mathematics must be presented in a more connected fashion for

students to increase their mathematical reasoning ability, it is irresponsible to think that students will be able to make all of these connections without the support of direct instruction.

The original hypothesis of this study involved a causal comparative study based on using the Connected Mathematics Project textbook series with a direct instructional approach versus the same textbook series with a constructivist instructional approach. The literature review was based on this hypothesis; however, the unavailability of data from constructivist-oriented classrooms caused a change in the study from causal comparative to a pre-post test design. The data from this study will determine if there has been a significant increase in eighth grade MAP math scores when the Connected Mathematics Project textbook series was employed in classrooms using direct instruction on a daily basis.

If the hypothesis for this study is proven to be correct, the results of this study will provide support for those districts seeking to make radical changes in curricula and while maintaining some aspects of a more traditional teaching methodology. However, if the hypothesis is proven to be incorrect, the results of this study will encourage districts to take pause and make more deliberate choices as they seek to find practices that will bring about increased MAP scores in mathematics.

Definitions of Terms and Symbols

The following terms and their definitions will be related to this study:

Adequate Yearly Progress-The Adequate Yearly Progress of a district is the annual target established to move in the direction of all students being proficient in reading and math by 2014.

Constructivism-The educational perspective that views students as being actively involved in building their own understanding.

DESE-The Department of Elementary and Secondary Education is the administrative arm of Missouri's State Board of Education.

Direct Instruction-Direct instruction is a teaching practice in which the teacher provides clear and focused instruction for specific skills and shows students how to apply skills in complex situations.

MAP Index Score-The MAP Index score is used to compare district performances on the MAP. It is calculated according to the following formula: MAP Index = (percentage of students at Step 1 X 1) + (percentage of students progressing X 1.5) + (percentage of students nearing proficiency X2) + (percentage of students proficient X 2.5) + (percentage of student advanced X 3).

Missouri Assessment Program-The Missouri Assessment Program is a series of performance-based tests designed to measure progress toward academic standards.

No Child Left Behind-The No Child Left Behind Act of 2001 is federal legislation designed to improve achievement in America's schools and will be more clearly defined in Chapter 2.

NSF-The National Science Foundation is an independent agency of the U.S. government that was created in 1950 to promote the sciences, advance the national welfare and prosperity, and secure the national defense.

Progressivism-The educational perspective that views students as learners requiring options for their education based on individual choice or societal need.

Show-Me Center-The Show-Me Center, based at the University of Missouri in Columbia works in partnership with four of the NSF-funded middle school math curriculum development centers to provide information and resources about the curricula.

Show-Me Standards-The Show-Me Standards were established by DESE and are comprised of 73 academic standards that provide a foundation of both knowledge and skills necessary for student success.

Standards-Based Curriculum-Standards-based curriculum refers to materials designed to address the strategies promoted in the NCTM Standards.

Standards-Based Mathematics-Standards-based mathematics is a methodology in which students engage in collaborative investigations and discussions to build their understanding of mathematics.

Limitations of the Study

The limitations of any study are directly related to the ability of a researcher to generalize the results from the study to another population of subjects. The implications of this particular studymay be limited by a few additional factors. Each factor will be discussed along with its potential impact. It is hoped that these factors will not have a detrimental impact on the overall validity of the proposed study.

Sample Size

The size of the sample will be affected by the number of responses to the survey. As the survey will be done via email and regular mail, this should make it easier for school personnel to have an opportunity to respond to the questionnaire.

Length of Usage of CMP

The amount of time that a district has used Connected Mathematics Project will influence the impact of that textbook series. If a district has only used parts of the materials for a couple of years or has had full implementation for less than three years, eighth grade students may not have had the opportunity to gain the full potential of the series.

CMP as Primary Text

School districts will utilize Connected Mathematics Project in a variety of ways. Some districts may use the series as their primary text with little or no supplemental materials. Other districts may use a different textbook series as

their primary text and use CMP to supplement it. This variance will be difficult to enumerate and should influence the performance of the students across the state.

CHAPTER TWO

Review of the Literature

Introduction

In order to understand the complex nature of the problem facing Missouri school districts in increasing student achievement in the area of math, literature related to government educational mandates, mathematics instruction, and mathematics curriculum must be examined. This chapter includes a review of the theory and research existing in these areas and a review of the Connected Mathematics Project curricula.

Government Educational Mandates

"If it seems no U.S. politician ever makes a speech today without insisting that education is his or her top priority, a quick glance back exactly 20 years may explain why that is" (Coeyman, 2003, p. 13) . "A Nation at Risk" published by The National Commission on Excellence in Education in April 1983 called to attention the problems facing America's educational system. In the face of rising competition from foreign countries, the report stated that "the time is long past when American's destiny was assured simply by an abundance of natural resources and inexhaustible human enthusiasm" and that America's world position was no longer "reasonably secure with only a few exceptionally well-trained men and women" (www.ed.gov/pubs/NatAtRisk/risk.html).

Government concern and involvement in public education certainly did not begin in 1983. As far back as the early 1800's,Thomas Jefferson stated that he knew "no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them but to inform their discretion" (to William Jarvis, 1820). Jefferson felt strongly that education needed to be one of his political platforms as illustrated by a quote made in 1818: "A system of general education, which shall reach every description of our citizens from the richest to the poorest, as it was the earliest, so will it be the latest of all the public concerns in which I shall permit myself to take an interest" (to Joseph Cabell, 1818). (The Jefferson quotes were taken from www.monticello.org/reports/quotes/education.html)

Thomas Jefferson was neither the first nor the last politician to speak in regards to educational interests. It is the recent comparison of America's students to their counterparts in the rest of the world that has sparked the current concerns and attempts on the behalf of government officials to remedy the situation. As reported by the commission in 1983:

> Part of what is at risk is the promise first made on this continent: All regardless of race or class or economic status, are entitled to a fair chance and to the tools for developing their individual powers of mind and spirit to the utmost. This promise means that all children by virtue of their own efforts, competently guided, can hope to attain the mature and informed judgment needed to secure gainful employment, and to manage their own lives, thereby serving not only their own interests but also the progress of society itself(www.ed.gov/pubs/NatAtRisk/risk.html).

The commission shocked the nation by naming thirteen indicators of the risk they saw in areas such as literacy and achievement. The majority of these indicators showed a decline in performance in test scores compared to past years and to scores from other countries.

After identifying the concerns, the commission produced findings regarding content, expectations, time and teaching intended to highlight the deficiencies in the educational process including, but not limited to:

1. a migration away from college preparatory toward general track courses.
2. a decrease in amount of homework.
3. a lack of experienced teachers and scholars involved in textbook writing.
4. the school day and calendar is shorter than many industrialized countries.
5. low salaries for teachers.
6. a shortage of teachers in critical areas like math and science.

Finally, the commission made recommendations to toughen high school requirements, raise standards for academic performance, increase time devoted to learning, and strengthen teaching requirements through increased training and professional growth (National Commission on Excellence in Education, 1983).

Twenty years after "A Nation at Risk", is there any indication that things have improved? The Koret Task Force on K-12 Education was commissioned by the Hoover Institution of Stanford University to examine the 1983 report and its findings. "The group examined public schools and found that fewer teachers

specialize in their subject areas than in 1983; the school year is still about seven days shorter than it was in the early 1970's; and students do no more homework than their counterparts did in 1982" (Coeyman, 2003, p. 13). The task force determined that three primary obstacles to educational reform were underestimated by the earlier commission: resistance to change on the part of the organized adult interests of the public education system, control of the teacher education process by post-secondary institutions who impose their own ideas regardless of effectiveness, and a widely held belief by the American public that their schools are educationally sound (Peterson, 2003).

In Our Schools and Our Future: Are We Still at Risk?, the Koret Task Force outlined their findings as follows:

> "The members of this task force have studied American education for many years...[and] we come together in unanimous support of the ten findings that... encompass the most important lessons we have learned... over the two decades since 'A Nation at Risk':
>
> 1. U.S. education outcomes, measured in many ways, show little improvement since 1970.
> 2. The U.S. economy has fared well during the past two decades not because of the strong performance of its K-12 system, but because of a host of coping and compensating mechanisms.
> 3. We've made progress in narrowing resource gaps between schools, communities, states, and groups, but the achievement gaps that vex us remain nearly as wide as ever.
> 4. The preponderance of school reform efforts since 'A Nation at Risk' has concentrated on augmenting the system's resources, widening its services, and tightening its regulation of school practices.
> 5. Higher-quality teachers are key to improving our schools, but the proper gauge to measure that quality has nothing to do with paper credentials or more resources and everything to do with classroom effectiveness.
> 6. Bold reform attempts have been implemented in limited and piecemeal fashion, despite their potential to improve student learning.

7. Standards-based reform has not achieved its full potential. Though promising, it is hard to get right.
8. Choice-based reforms have not had a fair test.
9. Americans need better, more timely information about student performance, not only at the national and international levels, but also for individual schools, pupils, and teachers.
10. We need a thoroughgoing reform of elementary and middle schooling." (Peterson, 2003, p. 11)

The task force concluded its findings with a recommendation that fundamental changes in the school's power structures are needed and that those changes revolved around a need for accountability through accurate assessments with real consequences, a need for increased parental choice and decreased bureaucracy, and a need for transparency through readily available information about schools and school systems.

The No Child Left Behind Act proposed by President George W. Bush in 2001 is the latest national attempt to address educational deficits. NCLB requires annual testing in reading and math for grades 3-8, requires parents to be informed when their schools are failing, and allows students at poor performing schools to receive an education at a higher-performing school. NCLB also sets targets for Adequate Yearly Progress. Schools that do not meet their AYP will be designated as a 'failing school'. The AYP is designed to provide incremental steps to move all students to 100% proficiency by 2014. In Missouri, the first true test will come in 2005 when the AYP for math increases from 10.3% to 31.1% (Table 1). This progression seems especially daunting when compared to the data from the Missouri Assessment Program for 1999-2003 (Table 2). In 2003, 13.9% of

eighth grade students and 12.3% of tenth grade students were proficient (Missouri Department of Elementary and Secondary Education, 2003).

The measures from NCLB would seem to address the three recommendations of the Koret Task Force in accountability, choice and transparency. The task force did note that the No Child Left Behind Act may move states and local school districts in the right direction of reform, but recognized that with its long timelines and minimal sanctions it may not bring about the desired results.

In Missouri, the Show-Me Standards were approved by the Missouri State Board of Education on January 18, 1996. These standards were developed in response to the Outstanding Schools Act of 1993. The standards are divided into performance (process) and knowledge (content) standards. The performance standards state that students in Missouri public schools will acquire the knowledge and skills to:

1. gather, analyze and apply information and ideas.
2. communicate effectively within and beyond the classroom.
3. recognize and solve problems.
4. make decisions and act as responsible members of society.

The knowledge standards identified what students should know and be able to do for communication arts, fine arts, health and physical education, mathematics, science, and social studies (www.dese.state.mo.us).

The Show-Me Standards led to Curriculum Frameworks and Grade Level Expectations for each of the subject areas. It is on the basis of these documents that the Missouri Assessment Program (MAP) is designed to assess if students are meeting these expectations. While DESE has stated that Missouri law assures local control of education, including curriculum choices, the expectations that districts are required to meet as part of the Missouri School Improvement Program are reflective of how students perform on the MAP tests. Therefore, to ensure the best performance, districts are forced to align their curricula to these state frameworks.

Mathematics Instruction

Models of mathematics instruction have varied during the past century. "It would be a mistake to think of the major conflicts in education as disagreements over the most effective ways to teach" (Klein, 2003, p. 2). Instead, the reasons for the revolving changes have focused on content (what to teach) and pedagogy (how to teach).

Progressivism

Progressivism has influenced American education for most of the 20th century. Due to the influences of John Dewey, progressivists believe that education should be primarily utilitarian in nature. William Heard Kilpatrick, a prominent professor at Columbia University, felt that the study of mathematics was unnecessary for ordinary living and disputed the notion that it contributed

to mental discipline. During a lecture at the University of Florida, Kilpatrick declared, "We have in the past taught algebra and geometry to too many, not too few" (Tennenbaum, 1951, p. 105). In a report commissioned by the National Education Association's Commission on the Reorganization of Secondary Education, Kilpatrick stated that "nothing in mathematics should be taught unless its probable value could be shown" (Klein, 2003, p. 3).

Progressive education continued to be advocated in the 1930s. "The school curriculum would be determined by the needs and interests of children, as determined by professional educators, and not by academic subjects" (Klein, 2003, p. 4). Several movements in the past century promoted this thinking.

The *Activity Movement* of the 1930s promoted integrated education instead of compartmentalized subjects This movement was embraced by elementary schools while secondary schools still saw the need for specific courses taught by teachers trained in that field. As part of this movement, some advocated for a lack of emphasis on learning multiplication tables.

The *Life Adjustment Movement* of the 1940s was a result of the nation's response to poorly trained military recruits with minimal knowledge of basic skills. "Education leaders presumed that 60% or more of all public school students lacked the intellectual capacity for college work or even for skilled occupations, and those students would need a school program to prepare them for every day living" (Klein, 2003, p. 5). Practical math courses were offered as an alternative to more rigorous courses. From 1909 to 1955, the percentage of

students taking advanced mathematics courses steadily declined. In 1909, 56.9% of high school students were enrolled in algebra, 30.9% of students were enrolled in geometry, and 1.9% of students were enrolled in trigonometry. By 1955, the numbers were down to 24.8% in algebra and 11.4% in geometry while trigonometry saw a slight increase to 2.6% (Jones and Coxford, 1970, p. 54). However, as a result of advances in science and technology in the mid-1900s, the importance of mathematics education was reestablished and the ideas of the progressivists faded from prominence for many years.

In the early 1970s, the *Open Education Movement* developed as a result of an influential book entitled Summerhill published in 1960. This book described an English boarding school in Suffolk that allowed students to determine their own learning. The author, Alexander Sutherland Neill, stated that "whether a school has or has not a special method for teaching long division is of no significance, for long division is of no importance except to those who want to learn it" (Klein, 2003, p. 8). The Open Education Movement promoted allowing children to choose learning activities through reading centers, play corners, and activity tables. The most notable downfall to this movement was the lack of outside resources available to disadvantaged children who were unable to gain the basic skills they were missing from school.

In the 1980s, a variant of progressivism known as *Constructivism* began to take hold. Constructivism is a learner-centered teaching model where students learn at their own pace and through their own discovery. In an analysis of

constructivism, Rachel Lucks (1999) stated that "learners use their own experiences to construct understandings that make sense to them. New learning depends on prior understanding and is interpreted in the context of current understanding, not first as isolated information that is later related to existing knowledge" (ematusov.soe.udel.edu/final.paper.pub/_pwfsfp/0000017b.htm). Learning activities in this model focus on authentic or "real world" tasks and on explanations and answers to situations found by the students through social interactions that are guided by the teacher.

Kids Do Count!, an internet site devoted to seeking excellence in mathematics education, is concerned with this approach. It states that constructivism:

> "means that students, with little assistance, are somehow to construct their own knowledge base of mathematical laws, formulas, and algorithms by self teaching. The vague hope is that kids can do this partly by inventing their own math techniques through extensive hands-on exploration (discovery), but with little help or explanation from the teacher. Thus the teacher is relegated to the role of watching and co-exploring, but seldom instructing" (snow.prohosting.com/mathiq/).

It also points out that allowing students to discover math on their own requires that the material be diluted due to time constraints.

It is interesting to note that the National Council of Teachers of Mathematics (NCTM) was created in 1920 largely in response to the progressivist agenda for mathematics. "The first NCTM president, C.M. Austin, made it clear that the organization would 'keep the values and interests of mathematics before the educational world'" (Klein, 2003, p. 4). However, in response to public outcry

"in support of a strong focus on basic skills and clear high standards, the NCTM took steps to recast its own agenda under the label of standards" (Klein, 2003, p. 11). The NCTM Standards, first developed in 1989, were comprised of sections for sections of grades (K-4, 5-8, and 9-12).

> "The NCTM Standards reinforced the general themes of progressive education, dating back to the 1920s, by advocating student centered, discovery learning. The utilitarian justification of mathematics was so strong that both basic skills and general mathematical principles were to be learned almost invariably through 'real world' problems. Mathematics for its own sake was not encouraged. The variant of progressivism favored by the NCTM during this time was called 'constructivism' and the NCTM Standards were promoted under this banner" (Klein, 2003, p. 13).

In the fall of 1989, a bipartisan educational summit met in Charlottesville, Virginia. According to Klein (2003), "participants… made a commitment to make U.S. students first in the world in mathematics and science by the year 2000" (p. 13) and called for national standards. Klein continued by saying that "the nation was looking for benchmarks that could improve education… and by default [the NCTM Standards] became the national model for standards" (p. 13)

New Math Education

Developed in the 1950s and 1960s, the New Math movement saw a shift in the importance of having curricula that provided clear explanations for mathematical procedures as opposed to ignoring them and focusing only on what is practical. Unlike many of the progressivist movements, mathematicians were involved in the development of this curricula.

> "Although there were important successes in the New Math period, some of the New Math curricula were excessively formal, with little attention to

> basic skills or to applications of mathematics. Programs that included treatments of number bases other than base ten, as well as relatively heavy emphases on set theory, or more exotic topics, tended to confuse and alienate even the most sympathetic parents of school children. There were instances in which abstractness for its own sake was overemphasized to the point of absurdity. Many teachers were not well equipped to deal with the demanding content of the New Math curricula" (Klein, 2003, p. 7).

Morris Kline developed a letter entitled *On the Mathematics Curriculum of the High School* where he stated that "mathematicians, reacting to the dominance of education by professional educators who may have stressed pedagogy at the expense of content, may now stress content at the expense of pedagogy and be equally ineffective" (www.michel.delord.free.fr/kline62.html). In the letter, Morris criticized the New Math and put forth the following practical guidelines for future curricula:

1. Curriculum should provide for the needs of all students.
2. Knowing mathematics means being able to use mathematical concepts with fluency.
3. Mathematics and science are integrally linked together.
4. Mathematical thinking is composed of inductive and deductive processes and extends beyond formal proofs.
5. It is beneficial to retrace the historical development of mathematical ideas.
6. Traditional math courses are not the problem; the problem lies with teaching those subjects in isolation from other subject areas.
7. Modern math courses need to develop the same coherence and unity in its general concepts that traditional courses offer.

Direct Instruction

When used with a lowercase "d" and "i", direct instruction refers to a pedagogy that focuses on "the use of carefully planned lessons, designed around a highly specified knowledge base and a well-defined set of skills" (www.aasa.org/Reform/Approach/direct.htm). When used with a capital "D" and "I", Direct Instruction refers to a specific curriculum and methodology that developed as result of work done by Siegfried Engelmann at the University of Illinois in the late 1960s. This work was later continued at the University of Oregon and specific materials were developed by Science Research Associates, a division of McGraw-Hill. This section will focus on the more general usage of the term "direct instruction."

According to Rachel Lucks (1999), direct instruction has several attributes. It is best used when presenting new material. Students need to be told what they will be learning and how it will be used. The teacher explains and models the new concept to the students. Multiple opportunities for practice, both guided by the teacher and independent, and feedback are essential. Many other types of instruction, such as cooperative groups, technology, and enrichment activities, can be incorporated into this model as long as it is carefully monitored by the teacher.

Critics of direct instruction have pointed to the low cognitive level of skills taught and stated that it is unsuitable for higher order thinking. Rosemary Kolstad and L.D. Briggs (1992) suggested that the problem lies in how direct

instruction is used. If the higher order thinking knowledge and skills desired are identified, lessons can be designed to incorporate those skills using the direct instruction method.

The National Education Association and the American Association of School Administrators in 1998 jointly commissioned an independent study of 24 educational approaches, one being direct instruction. The results of the study was published by the American Institutes for Research (AIR) (see Table 3).

"Only three of the approaches examined—Direct Instruction, High Schools That Work, and Success for All—provide strong evidence that they positively impact student achievement. For many of the approaches, surprisingly, there's little evidence one way or another on whether they help students achive. Some approaches are new and haven't yet conducted studies to establish a track record. Others haven't done so even though they've been used by schools for years" (www.nea.org/neatoday/9902/scoop.html).

Of the fourteen direct instruction studies reviewed by the AIR, eleven showed a positive effect on mathematics (Viadero, 1999). Engelmann, along with Gary Adams, completed a meta-analysis of direct instruction programs and found that 32 of 34 had a positive effect on student achievement (American Institutes for Research, 1999).

Math Wars

As a result of the publication of the NCTM Standards, "stylish pedagogical methods combined with rhetoric about higher order thinking while downplaying or condemning outright both computation skills and mathematical proof complete the package" of reform mathematics education , according to Paul Clopton, a cofounder of an informal organization known as Mathematically

Correct (mathematicallycorrect.com/reform/htm). This dichotomy between basic skills and conceptually thinking has incited what has come to be known as the "math wars." Does this dichotomy truly exist?

Dr. Hung-His Wu, a professor of mathematics at the University of California at Berkeley, believes this is a bogus dichotomy. He feels that there is a common misconception that acquiring basic skills is the opposite of conceptual thinking.

> "The truth is that in mathematics, skills and understanding are completely intertwined. In most cases, the precision and fluency in the execution of the skills are the requisite vehicles to convey the conceptual understanding. There is not 'conceptual understanding' and 'problem-solving skill' on the one hand and 'basic skills' on the other. Nor can one acquire the former without the latter" (Wu, 1999, p. 1).

If the mathematical procedures, or algorithms, are explained to students in a logical manner, they will build a mathematical understanding. Wu went on to explain that "the problem of rote learning then lies with inadequate professional development and not with the algorithm" (p. 7). Another concern that Wu points out is the danger of children developing their own algorithms that may be incorrect or may not be true in all circumstances and may not be caught by the teacher. Wu concluded his thoughts by stating, "As Euclid told King Ptolemy in the fourth century, B.C., there is no royal road to geometry. Neither is there a royal road to conceptual understanding. Let us teach our children mathematics the honest way by teaching both skills and understanding" (p. 7).

Wu is not alone is this thinking. David Ross, in his 2001 article entitled "The Math Wars," stated, "The best way to advance students' conceptual thinking about mathematics is to have them master the traditional algorithms" (www.ios.org/text/dross_math-wars.asp?). He went on to clarify what he believed conceptual thinking to be. Concepts are a result of information obtained through the senses by way of abstraction and a way to efficiently organize this information. They also tend to be automatic in nature, meaning that once obtained it does not require a lot of mental labor to repeat them. Ross stated:

> "This is why it is important to cultivate the habit of defining concepts, of consciously identifying the facts on which they are based. It is also why the practice of drilling students in rote mathematical procedures is dangerous. We have all known students who mastered algorithms but never grasped the underlying theory; sad to say, we have all know teachers who taught algorithms without understanding the underlying theory… It is good for students to experiment with 'devising their own strategies' in this manner. It is a way for them to explore the structure of the methods that they have been taught. But it is not the development of a 'meaningful computational algorithm'" (www.ios.org/text/dross_math-wars.asp?).

He also provided several reasons for teaching the traditional algorithms:

1. They provide good examples of conceptual method.
2. They allow problems to be done efficiently.
3. They provide students a conceptual structure on which they are based.

In a real sense, advocating the mastery of algorithms helps to establish one as an advocate for true conceptual thinking.

In all the debate as to which is more important, basic skills or conceptual understanding, it is important to not lose sight of the true goal for any model of

mathematical instruction. As Clopton said, "The real key to success is real mathematics achievement, and every effort should be made to foster this achievement" (mathematicallycorrect.com/reform.htm).

Mathematics Curriculum

The development of the NCTM Standards has resulted in recent changes in related curricula. "Instructional materials have a particularly important role in making these changes happen, for they affect the mathematics students encounter and how they encounter it, the processes students use, the way teachers teach, and what is assessed" (Trafton, Reys, and Wasman, 2001, 264). Achievement declines noted both before and after the release of "A Nation At Risk" seem to be related to a deterioration in the content of mathematics textbooks. Jeanne Chall and Sue Conrad, in studying texts from 1945 to 1975, stated, "On the whole, the later the copyright dates of the textbooks for the same grade, the easier they were, as measured by indices of readability level, maturity level, difficulty of questions, and extent of illustration" (1991, p. 2).

Similarly, James Hiebert felt that "the evidence indicates that the traditional curriculum and instructional methods in the United States are not serving our students well" (Reys, 2001, p. 6). As stated by Robert Reys, a mathematics professor at the University of Missouri-Columbia, "We must use our collective energies and wisdom to elevate our efforts to work together in

developing mathematics programs that help all students engage in learning relevant and challenging throughout their K-12 experience" (p. 6).

Development of Standards-Based Curricula

In an attempt to thwart this apparent decline in mathematics achievement, the National Science Foundation (NSF) played a critical role in the development and proliferation of standards-based mathematics curricula. The NSF began in 1991 by offering Systemic Initiatives grants to encourage states to align their standards to the NCTM Standards. These were followed in 1994 with Urban Systemic Initiative grants designed for local school districts in large cities.

Once states aligned their standards with NCTM, NSF recognized the need for "the creation and development of commercial mathematics curricula aligned to the NCTM Standards. In the decade of the 1990's, the National Science Foundation sponsored the creation of the following [middle school] mathematics programs: Connected Mathematics, Mathematics in Context, MathScape, MATHThematics, and Pathways to Algebra and Geometry (MMAP)" (Klein, 2003, p. 15).

Reys was able to observe a congressional hearing in February 2000 on the federal role in mathematics reform. In arguing against standards-based materials, one speaker compared America's students to guinea pigs and a parent testified that districts should obtain informed consent from parents before using untested programs. As the coauthor of a K-8 mathematics textbooks series, Reys responded by saying:

> "The NSF programs that receive the most intense criticism have undergone unprecendented field-testing over at least three years. They have been piloted, revised, then field-tested and revised again before they became available for widespread use. Data continue to be systematically collected, and this feedback is reflected in later editions. Although criticizing the philosophy or second-guessing the mathematical content of the materials is fair, suggesting that they have not been extensively field-tested with teachers and students is blatantly untrue" (2001, p. 6).

Reys also pointed to the same process that traditional materials have gone through during their development and their lack of a strong record of success.

Following the development of standards-based curricula, the NSF also established distribution centers for these materials. The K-12 Mathematics Curriculum Center, sponsored by the NSF and created in 1997, states that its mission is "to support school districts as they build an effective mathematics education program using curriculum materials developed in response to the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics*" (Klein, 2003, p. 16).

Characteristics of Standards-Based Curricula

Due to the large number of new mathematics programs that have been developed in recent years and the number of older programs that have attempted to revise their material to incorporate student application and problem-solving, teachers and administrators must use caution when evaluating and selecting a standards-based curriculum. "Programs designed from the outset to embody the mathematical approaches and pedagogical principles advanced by the Standards differ significantly from those that have retrofitted some new

activities and problems to an approach based primarily on teacher demonstration and student practice" (Goldsmith and Mark, 1999, p. 41).

How do traditional and standards-based materials differ? Paul Trafton, Barbara Reys, and Deanna Wasman (2001) described six central characteristics of standards-based materials as those which are comprehensive, coherent, develop ideas in depth, promote sense-making, engage students, and motivate learning.

"A primary concern in all curriculum reform is the inclusion of knowledge, understandings, processes, and skills that constitute competency in a field" (Trafton, Reys, & Wasman, p. 259). The first characteristic is a focus on core mathematics. "Standards-based curriculums focus on the big ideas in mathematics—those principles that govern the structure and functioning of the mathematical system" (Goldsmith and Mark, 1999, p. 41). Opponents of this type of curriculum contend that skill mastery is overlooked, but the skills are embedded in activities that also target other types of thinking skills.

Coherence has to do with the connections made between new knowledge and other mathematical ideas into a unified whole. An integrated approach to topics appearing at each grade level helps to foster connections. "Learning that is connected and 'hangs together' results in higher achievement, greater applicability, and less susceptibility to forgetting" (Trafton, Reys, & Wasman, p. 260).

Mathematical ideas in standards-based curricula reappear in increasingly complex forms as a student progresses through grade levels. Rather than

spending a cursory amount of time on several different mathematical topics, the curriculum fosters a more in-depth understanding of a few topics repeated as the student matures. "Important ideas are frequently introduced early in a student's school career and revisited continually throughout the grades, with the focus on developing deeper layers of sophistication" (Trafton, Reys, & Wasman, p. 261).

Mathematical materials encourage sense-making by allowing adequate time to explore ideas, create individual ways of looking at a problem, and share those ideas with others. As students learn with understanding, they increase "the ability to learn, remember, and use mathematics" and "develop confidence in their mathematical abilities" (Trafton, Reys, & Wasman, p. 262). The focus in standards-based materials must be two-fold: learn to compute accurately and understand the processes involved in the computation.

Standards-based mathematics engage students both physically and intellectually. Student interest should be capitalized upon and curiosity should be heightened. Tasks need to be hands-on in nature to help develop mathematical concepts. "In standards-based curricula, the use of contexts, problems, projects, and other tasks to engage students and to connect mathematical ideas provides a platform for learning and allows for the development of a belief that math is not only important but also interesting" (Trafton, Reys, & Wasman, p. 263).

The final characteristic, motivating learning, has always been a challenge in mathematics settings. While advances in technology have increased the need

for mathematical studies, it remains important to illustrate for students the relationship between mathematics and other disciplines. In a standards-based curriculum, "mathematics emerges from multiple contexts… to help students learn more, understand that mathematics is useful, and realize that knowledge is not just an end in itself but a tool for solving problems" (Trafton, Reys, & Wasman, p. 264).

Goldsmith and Mark also discussed the need for a curriculum that meets the needs of all students as opposed to an elitist curriculum designed to be understood by a few talented students. "The developers of standards-based curriculums have addressed this issue by creating lessons with multiple entry points so that students with different levels of mathematical sophistication and different learning styles can engage with the mathematical ideas" (p. 43). Standards-based programs must provide support to teachers trying to meet the needs of a wide range of students with different abilities and interests.

Barbara Reys, Eric Robinson, Sheila Sconiers and June Mark (1999) also studied the characteristics of the standards-based curricula proposed by the NSF for the purpose of informing teachers, administrators and parents about these programs. They concluded that these materials introduced important mathematical concepts, emphasized understanding through applications with high student interest, provided for student interaction, incorporated the use of technology, offered opportunities for professional development, and provided the foundation for courses in high school.

Selection and Implementation

A brochure published by the Show-Me Center entitled "Implementing Standards-Based Mathematics Curricula" provided helpful information to prepare districts and their stakeholders for the change. The Center identified four key steps for district personnel to take before adopting this type of curricula:

1. Gather evidence on how students are performing, including strengths and weaknesses, and request data from publishers about their curricula's effectiveness.
2. Obtain support from administrators, parents, and teachers.
3. Address issues related to basic skill instruction, curriculum usage across grade levels and course sequencing, and state expectations.
4. Enable teacher buy-in and success by piloting units, developing an implementation schedule, and designating teacher leaders.

Addressing these needs early in the process is critical to implementation success (showmecenter.missouri.edu/resources/implementation.pdf).

The Show-Me Center brochure also stressed the importance of professional development. "The focus of professional development for teachers implementing a standards-based curriculum is to enable teachers to learn mathematics content and pedagogy needed to plan their instruction around these curricula" (p. 2). This process must begin early in the process and allow for time to address concerns. As new teachers join the district, a training plan is needed for them. The professional development plan should cover three to four

years and revolve around the topics of experiencing, planning, teaching, reflecting and professionalism (see Table 4). The brochure concluded by stating, "Another way to view the professional development model is through the lens of these four roles: Teachers as students of mathematics… as teachers of mathematics… as collaborators with other teachers… as change agents working with administrators, parents, and other teachers" (p. 10).

Former NCTM president Lee V. Stiff provided several criteria for selecting curriculum materials. He stated:

> "They must provide sound and developmentally appropriate mathematics content. They must build on and expand the content knowledge and pedagogical behaviors of teachers without being either too difficult for teachers to understand and implement or to traditional to promote the vision of the *Standards*. They must use assessment as a teaching and learning tool. They must help teachers increase their understanding of mathematical content and best teaching practices. There is no one correct way to teach mathematics. As the journey of teaching and learning mathematics continues, the need to identify instructional materials that complement teachers' personal and professional development in the understanding and implementation of the NCTM *Standards* will always be with us. The key to making good decisions about the selection of teaching materials is recognizing that teachers must be challenged to take manageable steps over time toward the vision of a high-quality mathematics education for every child" (www.nctm.org/news/pastpresident/2001-10president.htm).

When selecting materials, it is essential to consider teacher effectiveness and ongoing professional development for its implementation.

Jennifer Bay and Barbara and Robert Reys (1999) identified ten factors that should be considered when implementing a standards-based curriculum. They based these factors on surveys of over 100 middle school teachers and administrators who participated in the Missouri Middle-school Mathematics

(M3) Project for three years. The project focused on awareness of the NCTM Standards and investigation and utilization of four of the curricula funded by the NSF: Connected Mathematics Project, Mathematics in Context, MathScape, and Math Thematics. They asked the teachers involved with the project to identify the major challenges they had faced, the supports they received during implementation, and the advice they would offer to those considering the adoption of one of these curricula. The following are the ten elements they identified as critical to implementing a standards-based mathematics curricula:

1. Administrative support through active participation in the process and the provision of release time for teachers.
2. Opportunities to study the Standards and curricula.
3. Sampling the curricula and trying it out with students.
4. Common daily planning times to review progress and pacing of material.
5. Interaction with experts and opportunities to observe experienced teachers.
6. Collaboration time with colleagues beyond daily planning to share ideas and discuss issues.
7. Incorporating new forms of assessments.
8. Communicating with parents to inform them of changes and their rationale.
9. Helping students adjust to new style of learning mathematics.
10. Planning for transition to high school.

They concluded their study by saying, "Unlike textbook adoptions, which require the expenditure of many hours on selection... the kind of implementation we witnessed... required hundreds of hours for change to occur" (p. 506). School personnel must be prepared to commit to the process beyond the present year and the process requires stamina.

Role of Assessment

The Show-Me Center also produced a brochure on assessment. "The Role of Assessment in Standards-Based Middle School Mathematics Curriculum Materials" defines various purposes: to improve learning, to monitor and document student progress, to help teachers make informed instructional decisions, to allow students to demonstrate and reflect on their growth, and to evaluate student achievement. The primary focus of classroom assessment in a standards-based program is formative in nature and used to "gather information on what students know and what they can do" (p. 3).

Assessment can be both formal and informal. Formal assessments are specific and defined, such as quizzes, tests or projects. Informal assessments are more general and include "observing and listening to students as they work..., collecting and reviewing student work and interviewing students" (p. 4). Informal assessments tend to be an ongoing process.

The Show-Me Center also promotes involving students "in their own assessment through portfolios and self-assessment scales" (p. 9) and advocates the use of rubrics for scoring student work. "The teacher guides of [standards-

based curricula] provide support for teachers in designing, using and valuing assessment" (p. 14) and the Center recognizes that these formats of assessment may be new to mathematics teachers.

Problems and Criticism

Standards-based curricula are not without criticism. Shortly after the announcement by the U.S. Department of Education endorsing ten mathematics programs as "exemplary" or "promising", six university mathematics professors (along with about 200 other co-signers) wrote a letter to Richard Riley, Secretary of Education. The letter was published as a full-page ad in the Washington Post on November 18, 1999. In the letter, the authors expressed concern that the final decisions of the department were from an Expert Panel that did not include any active research mathematicians. The letter also pointed to specific concerns with some of the curricula:

1. The Connected Mathematics Project omits the topic of division of fractions.
2. MathLand does not include any mention of the standard method of multiplication.

They concluded the letter by calling for a review of these programs that included mathematicians and urging "that school districts not take the words 'exemplary' and 'promising' in their dictionary meanings, and exercise caution in choosing mathematics programs" (mathematicallycorrect.com/riley.htm).

David Klein (2003), one of the co-authors of the letter, has cited several problems with the standards-based curricula. They overemphasize data analysis, statistics, and real world applications. Student discovery through group work is the preferred method of learning and calculator use is encouraged excessively. The programs fail to develop fundamental arithmetic and algebra skills. "Arguably the most hierarchical of human endeavors, mathematics also depends on sequential mastery of basic skills" (Klein, 2000, p. 53).

The reduction of teacher-led instructional time is also concern. "The high-performing Japanese students spend 80 percent of class time in teacher-directed whole-class instruction" (Klein, 2000, p. 57). According to Hung-Hsi Wu, "when cooperative learning rules, teachers cannot share their insights with students or warn them against pitfalls" (1997, p. 6).

Connected Mathematics Program

The Connected Mathematics Project is a curriculum that was developed through funding provided by the National Science Foundation. Work on the curriculum was done primarily at Michigan State University between 1991 and 1997. It was the only middle school mathematics curriculum to receive an "exemplary" rating by a national panel of experts. "The overarching goal of Connected Mathematics is to help students and teachers develop mathematical knowledge, understanding, and skill, as well as an awareness and appreciation

of the rich connections among mathematical strands and between mathematics and other disciplines" (Rivette, et al, 2003, p. 4).

Components of CMP

Connected Mathematics is composed of twenty-four units—eight per grade level—that incorporate the mathematical strands of number sense, geometry, measurement, statistics, probability and algebra. Units are taught in five to eight weeks; therefore, it is not possible to cover all twenty-four units in three school years. Some unit are considered to be optional and for enrichment purposes, so there is flexibility in the timing of the units taught.

Cain (2002) described typical units for each grade level. The topics tend to be repeated in units making CMP a spiral curriculum. Sixth grade covers units on the collection and analysis of data, fractions, decimals, percents, properties of shapes, area, perimeter, and number theory. In seventh grade, students revisit the topics of fractions, decimals and percents. New topics include probability, similar figures, variables, patterns, and the use of graphing calculators. Eighth graders extend their knowledge by studying proportions, the Pythagorean theorem, and volume and surface area.

Elements of Lesson Investigations

Unlike direct instruction lessons where material is presented by a teacher and then practiced by the students, Connected Mathematics lessons are characterized by student investigations.

> "Investigations are generally structured into three main phases: launch, explore, and summarize. In the launch phase, a problem context is established and clarified and work expectations are communicated. In the explore phase, students work to solve problems. In the summarize phase, students look for connections, patterns, and relationships in their own thinking and the mathematical content. In each of these phases, however, daily lessons can be structured in quite different ways. Each phase can include a mix of teacher presentation, small-group work with two to five students, and whole-class discussion. This mix of instructional formats means that the content and sequence of activities in consecutive days' lessons can be quite different" (Starr, Herbel-Eisenmann, and Smith, 2000, p. 449).

This variety of daily instructional formats and sequencing of phases is more student-centered and helps them gain a better understanding of the concepts.

Cost of Program

CMP materials tend to cost less than other traditional math textbooks. Materials for approximately 200 sixth grade students would be approximately $6,200 as compared to $8,000-$10,000 for other textbooks. However, providing the appropriate professional training and development for teachers would more than make up for those differences in cost of materials. As discussed earlier, this training is essential to implementing any new standards-based curriculum (Cain, 2000).

Summary of Related Research

Zawojewski, Robinson and Hoover (1999) studied the effectiveness of Connected Mathematics on conceptual understanding over time. On the basis of classroom observations and student sample work, they analyzed how sixth, seventh and eighth grade students approached a similar task involving the area

of a circle. "Students' methods of finding area... seemed to fall into three categories: using a qualitative sense of area, counting squares that cover the region, and using the formula for the area of a circle" (p. 325). Sixth grade responses typically did not include the use of the formula for the area of a circle despite covering that in the sixth grade units. However, the seventh and eighth grade responses tended to have more accurate calculations and clearer communications of their approaches. As students moved up in grade level, the more words that students used in their explanations and the clearer their reasoning.

> "The overall curriculum is notable in that each year, students are introduced to a small number of important mathematical ideas that are each explored in depth beginning with the foundational concepts and progressing to the formal mathematical conventions. Reteaching the same ideas from year to year seldom occurs, yet students are expected not only to use concepts and skills previously introduced but to become more sophisticated in their use. The challenging applied problems found throughout the curriculum are designed so that students can use a variety of conceptual approaches after their initial introduction to new content and over time master conventional methods and procedures" (p. 327).

The researchers concluded that the curriculum "addresses geometry seriously" at the middle school level (p. 327) and that the analysis of student work and approaches can provide valuable insight for teachers using the curriculum.

Cain (2002) studied the impact of Connected Mathematics on the Lafayette Parish school district, the first district in Louisiana to adopt the curriculum. Sixth and seventh grade students take the Iowa Test of Basic Skills (ITBS) and eighth grade students take the Louisiana Educational Assessment Program (LEAP). The

tests taken in 1998-1999 were the first to reflect the change in curriculum. The sixth grade students scored 16% higher than students not using CMP. Seventh grade students scored 9% higher than students not using CMP. At the eighth grade level, students had an 86% passing rate compared to 70% for students who had not used CMP. The same comparisons were made in the 1999-2000 school year. Sixth and seventh grade students scored 10% higher, while eighth grade students had an 87% passing rate compared to 77% for students who had not used CMP.

In addition to the quantitative data from student test scores, Cain (2002) surveyed twenty-eight teachers about their perceptions of CMP:

- 93% liked CMP better than other math programs they had taught
- 93% felt they had a better understanding of math by teaching CMP
- 93% believed their students were better problem solvers
- 90% felt that the curriculum was more challenging
- 100% found the CMP training beneficial

Teachers also felt that the communication and reading skills of their students were improved. With Connected Mathematics students learn more than one way to approach a problem. Teachers liked the interactive nature of the program and the emphasis on critical thinking and communication skills. Things they liked least about the program included grading papers, needing more basic review and drill, and managing group activities. When asked about the amount of planning needed, responses ranged from ten minutes per day to five hours per

week. About half of the teachers responded they needed three or more hours per week to plan lessons usingConnected Mathematics .

Riordan and Noyce (2001) researched the effectiveness of the Connected Mathematics Project curriculum on state test scores in Massachusetts. Schools were selected for the study based on how long the program had been implemented and how many of the units had been used. Comparison schools were selected based on performance on state tests and socioeconomic status of students in an attempt to make the schools as similar as possible to limit significant differences. They found that student scores on the Massachusetts Comprehensive Assessment System (MCAS) were higher for students in the schools using CMP. Specifically, students in schools that had used CMP for two or three years scored 4.0 points better than their comparison group. Students in schools that had used CMP for four years scored 5.5 points better than their comparison group.

Reys et al. (2003) researched the use of Connected Mathematics in a Missouri school district. Students took the same course in sixth grade using CMP. About 75% of seventh grade students continued to use CMP while the other 25% took prealgebra and used CMP as a supplemental text. In eighth grade, 70% used CMP as their primary text while the other 30% used CMP as a supplemental text for an Algebra I course. In the comparison district, all sixth and seventh grade students took the same course. 40% of eighth grade students were enrolled in prealgebra and 60% were enrolled in Algebra I. The MAP scores

for students in these districts were compared in 1999. The percentage of students for each level of the MAP is shown below (p. 83):

	CMP District	Non-CMP District
Step 1 and Progressing	35%	32%
Nearing Proficiency	36%	34%
Proficient and Advanced	30%	34%

The researchers found that the comparison district, who had a higher percentage of students enrolled in Algebra I, did not score as high as the standards based district when comparing the algebra strand items on the test. Overall, both districts had a higher percentage of students in the proficient and advanced levels of the MAP as compared to the state average of 10.3% (see Table 2). However, the non-CMP district did have 4% more students at these levels than the district using CMP.

CHAPTER THREE

Methodology

Overview

This research was a pre-post test study using an independent and dependent variable. The independent variable was the use of direct instruction in combination with the Connected Mathematics Project in the state of Missouri. Districts using CMP were mailed surveys requesting information about how the curriculum was implemented. The dependent variable was the eighth grade mathematics MAP scores for those districts. MAP data from the eighth grade mathematics test for districts using CMP in conjunction with direct instruction on a daily basis was analyzed to see if there was a significant increase in the MAP scores after implementing CMP.

Research Methods

The study began by identifying the top performing middle schools in mathematics in Missouri. This information was obtained from DESE's website. The top ten schools in average percent of students scoring at the "proficient" and "advanced" levels of the eight grade mathematics MAP test, 1998-2002, were categorized according to school size. An email was sent on June 20, 2003, to twenty-six districts. After receiving one response, a second email message was

sent on June 25, 2003. A total of five districts responded to this request for information. One of those districts used CMP.

Information was requested from Paul Waterhouse, an area sales representative for Prentice-Hall, as to the schools anddistricts that have purchased CMP materials from 2000 to 2002. From this list, a survey was mailed to sixteen districts. Five districts returned the survey. Three of these districts indicated that they do not use Connected Mathematics.

Subjects

The three districts utilizing CMP that responded to the surveys were the subjects of this study. These districts have been designated as D1, D2, and D3. All three districts are located in St. Louis County. The information in Chapter Four for each district, including the information included in Figure 1, was obtained from DESE's 2003-2004 Missouri School Directory on their website.

Instrumentation

The selected instrument for this study is the Missouri Assessment Program (MAP) test for eighth grade students in the area of mathematics. Students are ranked according to five steps: Advanced, Proficient, Nearing Proficiency, Progressing, and Step 1. Students ranked as Advanced or Proficient are deemed to have met the national standards for *No Child Left Behind*.

Procedures

Information pertaining to the subject districts, including MAP scores, was obtained from DESE's Missouri 2003-2004 School Directory. This can be found on their website. Due to the fact that this information is in the public domain, no consent was requested for their inclusion in this study.

CHAPTER FOUR

Results

Description of the Sample

District D1 has an assessed valuation of $2.6 billion and a tax levy of $4.438. They have six middle schools with 5269 resident students and one non-resident student. 83.64% of district students are white. In 2004, they had 1,760 eighth grade students accountable for the MAP test. Only 0.7% of those students received a "Level Not Determined" rating on the mathematics test

District D2 has an assessed valuation of $829 million and a tax levy of $3.36959. They have one middle school with 592 resident students and five non-resident students. 67.64% of district students are white. In 2004, they had 199 eighth grade students accountable for the MAP test. Only 2% of those students received a "Level Not Determined" rating on the mathematics test.

District D3 has an assessed valuation of $341 million and a tax levy of $4.0039. They have one middle school with 633 resident students and no non-resident students. 83.39% of the middle school students were white. In 2004, they had 200 eighth grade students accountable for the MAP test. None of those students received a "Level Not Determined" rating on the mathematics test.

Figure 1

Comparison of Subject District and Missouri State Data

School Data	District D1	District D2	District D3	State
Attendance Rate	95.30%	95.10%	94.50%	93.7%
Student: Classroom Teacher	18:1	12:1	17:1	18:1
Student: Administrator	243:1	155:1	214:1	205:1
Teachers with Advanced Degrees	63.37%	84.53%	61.24%	51.08%
Average Teacher Salary	$44,781	$56,786	$42,069	$37,641
Per Pupil Expenditure	$7074.23	$13,583.34	$7039.20	$7345
Students Eligible for Free/Reduced Lunch	13.02%	15.36%	23.40%	39.21%

Research Design

This project was a pre-post test design using eighth grade mathematics MAP scores from 1999 and 2004 for the subject districts who indicated that they utilized the Connected Mathematics Project curricula. These scores were compared to the overall state scores from those same years. The subject district test scores from this instrument were compared to the state average in the following two areas: percentage of students proficient or advanced and the MAP Index score (see Figures 2 and 3).

Figure 2

Percentage of Students Proficient or Advanced

Year	1999	2004	Net Gain
State	10.4	13.9	3.5
District D1	18.5	26.8	8.3
District D2	29.5	30.8	1.3
District D3	17.8	15.5	-2.3

Figure 3

MAP Index Scores

Year	1999	2004	Net Gain
State	164	173.4	9.4
District D1	180.5	194.3	13.8
District D2	193.3	195.4	2.1
District D3	176.2	177.3	1.1

Research Question

Is there a statistically significant increase in the test scores from 1999 to 2004 for the three subject districts using CMP?

Statistical Treatment of Data

A general observation of Figures 2 and 3 indicates that District D1 is the only district out of the three subject districts to perform better than the state average on both the increase in percentage of students scoring at Proficient or Advanced and in the MAP Index. Districts D2 and D3 performed lower than the state average.

The performance of the three subject districts was also analyzed using more formal statistical measures (see Figure 4). Due to the fact that the data being compared involve the percentage of students scoring at the Proficient and Advanced levels, z-scores were calculated to determine the difference between these proportions. A one-tailed test was used to determine if MAP scores increased for the subject districts. The null hypothesis was that there was no difference in the proportions (H_o: $p_1=p_2$). The hypothesis was that there would be an increase in scores (H_1: $p_2>p_1$).

The P-value when comparing the percentage of students scoring at the Proficient and Advanced levels for District D1 was less than 0.00003. The P-value for District D2 was 0.4168. No z-test was done for District D3 due to the obvious decrease in the percentage of students scoring at the Proficient and Advanced levels. For District D1, the P-value was less than the significance level ($\alpha=0.05$) so the null hypothesis is rejected. For District D2, the P-value was greater than the significance level so the null hypothesis is accepted.

Figure 4

z-Test Comparing Subject Districts' MAP Performance
Percentage of Students Scoring Proficient or Advanced

	District D1	District D2
2004 (p_2)	0.185	0.298
1999 (p_1)	0.268	0.308
2004 (n_2) Number of students	1706	174
1999 (n_1) Number of students	1760	199
z-score	5.832	0.2096
P-value	< 0.00003	0.4168

CHAPTER FIVE

Summary and Discussion

Introduction and Overview

The discussion of the results of the study will be presented as follows: results relating to the research question, conclusion of the study, and implications for future research.

Results Related to the Research Question

The z-test for District D1 indicated a significant increase in test scores from 1999 to 2004. The z-test for District D2 indicated that they did not experience a significant increase in their test scores. As stated in Chapter Four, a z-test was not done on District D3 as their scores decreased from 1999 to 2004.

Conclusions of the Study

The following conclusions can be drawn from this study of the effectiveness of the Connected Mathematics materials on improving student performance on the MAP:

- Of the three districts studied, only District D1 had a higher net gain on their 8th grade mathematics MAP scores from 1999 to 2004 that the state net gain during that same time period.

- Districts D2 and D3 had lower net gains than the state net gain during this same time period.
- District D3 actually had a decrease in the percentage of students scoring in the Proficient and Advanced steps of the MAP from 1999 to 2004.
- The z-tests done in this study showed a significant increase in the proportion of students scoring at the Proficient and Advanced levels for District D1 but not for D2 or D3.
- The results of this study are inconclusive due to the limited number of subject districts reviewed. If more districts had responded to either the mailed survey or the email survey, more subject districts could have been studied and the results of the study may have been more conclusive.

Table 1

Adequate Yearly Progress in Math
2002-2014

Year	AYP
2002	8.3
2003	9.3
2004	10.3
2005	31.1
2006	32.1
2007	33.1
2008	54.2
2009	55.2
2010	56.2
2011	77.1
2012	78.1
2013	79.1
2014	100

Information taken from NCLB Accountability Presentation on August 15, 2003.
(www.dese.state.mo.us/divimprove/nclb/nclb/)

Table 2

Missouri Assessment Program
State Average Math Scores
1999-2003

Year	1999	2000	2001	2002	2003
4th grade advanced	6.40%	8.00%	8.20%	7.70%	6.60%
4th grade proficient	28.90%	28.70%	29.40%	29.90%	30.60%
4th grade total	**35.30%**	**36.70%**	**37.60%**	**37.6%**	**37.20%**
8th grade advanced	0.60%	1.20%	1.40%	1.20%	1.10%
8th grade proficient	9.70%	12.80%	13.40%	12.50%	12.80%
8th grade total	**10.30%**	**14.00%**	**14.80%**	**13.70%**	**13.90%**
10th grade advanced	0.50%	0.40%	1.00%	0.80%	0.80%
10th grade proficient	9.20%	9.90%	11.80%	9.90%	11.50%
10th grade total	**9.70%**	**10.30%**	**12.80%**	**10.70%**	**12.30%**

Information obtained from the Missouri Department of Elementary and Secondary Education website.
(www.dese.state.mo.us/divimprove/assess/stateresults.html)

Table 3: Approaches to Mathematics Instruction

Summary Table of All 24 Approaches

	Evidence of positive effects on student achievement[2]	Year introduced in schools	Number of schools	Support developer provides schools	First year costs[3]	First-year costs with current staff reassigned
Accelerated Schools (K-8)	◔	'86	1000	◑	$27	$14
America's Choice (K-12)	?	'98	300	●	$190	$90
ATLAS Communities (PreK-12)	?	'92	63	◑	$98	$90
Audrey Cohen College (K-12)	?	'70	16	◑	$161	$86
Basic Schools Network (K-12)	?	'92	150	◑	$12	NC
Coalition of Essential Schools (K-12)	○	'84	1000	◔	NA	NA
Community for Learning (K-12)	◑	'90	92	●	$157	$82
Co-NECT (K-12)	?	'92	75	●	$588	NC
Core Knowledge (K-8)	◑	'90	750	◑	$56	NC
Different Ways of Knowing (K-7)	◑	'89	412	●	$84	NC
Direct Instruction (K-6)	●	Late 60's	150	◑	$244	$194
Expeditionary Learning Outward Bound (K-12)	◑	'92	65	●	$81	NC

The Foxfire Fund (K-12)	?	'66	NA	◔	$65	NC
High Schools That Work (9-12)	●	'87	860	●	$48	NC
High/Scope (K-3)	◔	'67	27	●	$130[4]	NC
League of Professional Schools (K-12)	◔	'89	158	◑	$13	NC
Modern Red Schoolhouse (K-12)	?	'93	50	●	$215	NC
Onward to Excellence (K-12)	◔	'81	1000	●	$72	$60
Paideia (K-12)		'82	80	◑	$146	$96
Roots and Wings (PreK-6)	◔	'93	200	●	$270	$70
School Development Program (K-12)	◑	'68	700	◑	$45	$32
Success for All (PreK-6)	●	'87	1130	●	$270	$70
Talent Development High School (9-12)	◔	'94	10	●	$57	$27
Urban Learning Centers (PreK-12)	?	'93	13	◑	$169	$159

● = Strong ◑ = Promising ◔ = Marginal ○ = Mixed, Weak
?= No Research **NA**= Not Available **NC**= No Change

[1] This table summarizes information from *An Educators' Guide to Schoolwide Reform.*

[2] Although many types of student outcomes are important, evidence of positive effects on student achievement is a key consideration in selecting schoolwide reforms. However, some schools may wish to consider a new approach that has not yet developed strong evidence of effectiveness, but provides the strongest match with school goals.

[3] Costs are in thousands of dollars (e.g., $62=$62,000).

[4] The estimate for High/Scope assumes a school of 25 K-3 teachers.

Table 4

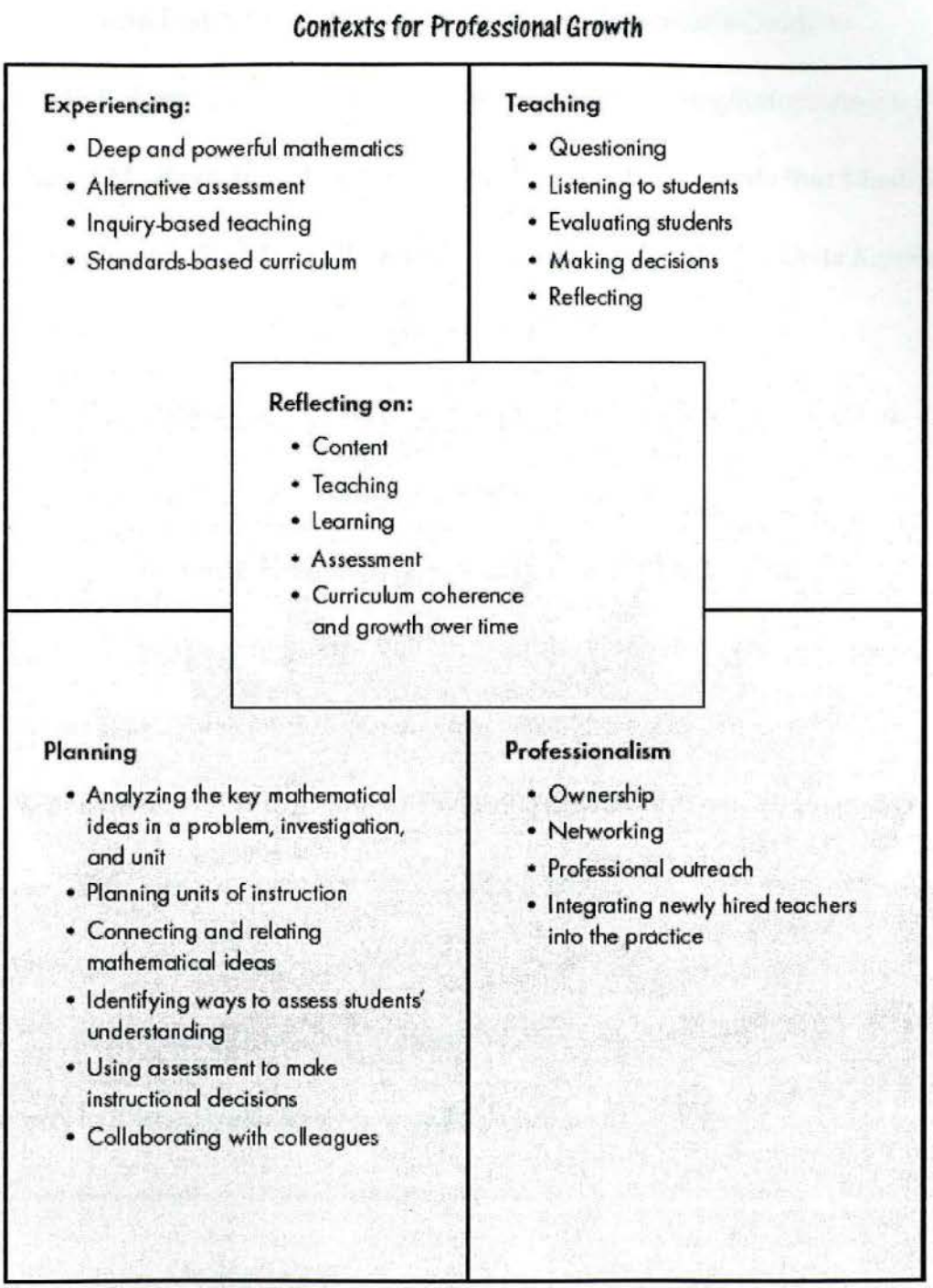

Figure taken from "Implementing Standards-Based Mathematics Curricula". (showmecenter.missouri.edu/resources/implementation.pdf)

REFERENCES

American Institutes for Research (1999). An Educator's Guide to Schoolwide Reform. Available online at http://www.aasa.org/Reform/index.htm

Bay, J.M., Reys, B., & Reys, R. (1999). The Top 10 Elements that Must Be in Place to Implement Standards-Based Mathematics Curricula. *Phi Delta Kappan*, 80 (7), 503-506.

Bush, President George W. (2001). Remarks by the President to 2001 National Urban League Conference. Available online at http://www.whitehouse.gov/news/releases/2001/08/20010801-1.html

Cain, Judith S. (2002). An Evaluation of the Connected Mathematics Project. *Journal of Educational Research*, 95 (4), 224-234.

Chall, Jeanne S. & Conrad, Sue S. (1991). Should Textbooks Challenge Students? The Case for Easier or Harder Textbooks. New York: Teachers College Press.

Clopton, Paul (Unknown). Reform Mathematics Education: How to "Succeed" Without Really Trying. Available online at http://mathematicallycorrect.com/reform.htm

Coeyman, Marjorie (2003). Twenty Years after 'A Nation at Risk'. *The Christian Science Monitor*, April 22, 2003, 13. Available online at http://www.csmonitor.com/2003/0422/p13s02-lepr.html

Goldsmith, L., & Mark, J. (1999). What is a Standards Based Mathematics Curriculum? *Educational Leadership*, 57 (3), 40-44.

Haycock, Kati (2001). Improving Achievement and Closing Gaps Between Groups. Missouri Legislative Forum 2000 Briefing Book Series. http://www.moforum.org/2000/building/student/part6.cfm

Jones, Phillip & Coxford, Arthur (1970). Mathematics in the Evolving Schools: A History of Mathematics Education in the United States and Canada. Reston, VA: National Council of Teachers of Mathematics.

Kids Do Count! Perspectives. Available online at http://snow.prohosting.com/math/iq

Klein, David (2003). A Brief History of American K-12 Mathematics Education in the 20th Century. Published in *Mathematics Cognition*, James Royer, ed. Greenwich, CT: Information Age Publishing. Available online at http://www.csun.edu/~vcmth00m/AHistory.html

Klein, David, et al (1999). An Open Letter to United States Secretary of Education, Richard Riley. Originally published as a full-page ad in the Washington Post. Available online at http://mathematicallycorrect.com/riley.htm

Klein, David (2000). Math Problems: Why the U.S. Department of Education's Recommended Math Programs Don't Add Up. *American School Board Journal*, 187 (4), 52-57.

Kline, Morris (1962). On the Mathematics Curriculum of the High School. Published in the March 1962 editions of *The Mathematics Teacher* and *American Mathematical Monthly*. Available online at http://michel.delord.free.fr/kline62.html

Kolstad, Rosemarie & Briggs, L.D. (1992). Direct Instruction Can Produce Critical Thinking in Mathematics. *Journal of Instructional Psychology*, 19 (4), 262-265.

Lucks, Rachel (1999). Constructivist Teaching Vs. Direct Instruction. This paper written as part of her coursework is available online at http://ematusov.soe.udel.edu/final.paper.pub/_pwfsfp/0000017b.htm

Missouri Department of Elementary and Secondary Education (2004). Information related to the Missouri Assessment Program, No Child Left Behind and relevant data available online at http://www.dese.state.mo.us

The National Academies (2003). Developing Mathematical Skills and Knowledge. Available online at http://www4.nas.edu/onpi/webextra.nsf

National Center for Education Statistics (2003). Comparative Indicators of Education in the United States and Other G8 Countries: 2002 (NCES 2003-026). Washington, D.C.: U.S. Department of Education.

National Commission on Excellence (1983). A Nation at Risk: The Imperative for Educational Reform. Washington, D.C.: U.S. Government Printing Office. Available online at http://www.ed.gov/pubs/NatAtRisk/index.html

National Education Association (1999). Facts, Not Fads, on Schoolwide Reform. *NEA Today*, February 1999. Available online at http://www.nea.org/neatoday/9902/scoop.html

Peterson, Paul (2003). Our Schools and Our Future: Are We Still at Risk? Stanford, CA: Hoover Press.

Reys, B., Robinson, E., Sconiers, S., & Mark, J. (1999). Mathematics Curricula Based on Rigorous National Standards: What, Why, and How? *Phi Delta Kappan*, 80 (6), 454-456.

Reys, Robert (2001). Mathematics Curricula and Guinea Pigs. *Mathematics Teacher*, 94 (1), 6.

Reys, R., Reys, B., Lapan, R., Holliday, G., & Wasman, D. (2003). Assessing the Impact of Standards-Based Middle Grades Mathematics Curriculum Materials on Student Achievement. *Journal for Research in Mathematics Education*, 34 (1), 74-95.

Riordan, Julie and Noyce, Pendred (2001). The Impact of Two Standards-Based Mathematics Curricula on Student Achievement in Massachusetts. *Journal for Research in Mathematics Education*, 32 (4), 368-398.

Rivette, Kelly et al (2003). Connected Mathematics Project: Research and Evaluation Summary. Upper Saddle River, NJ: Pearson Prentice Hall.

Ross, David (2001). The Math Wars. *Navigator*, 4 (5). Available online at http://www.ios.org/text/dross_math-wars.asp?

Show-Me Center. Implementing Standards-Based Mathematics Curricula: Preparing the Community, The District, and Teachers. Available online at http://showmecenter.missouri.edu/resources/implementation.pdf

Show-Me Center. The Role of Assessment in Standards-Based Middle School Mathematics Curriculum Materials. Available online at http://showmecenter.missouri.edu/resources/assessment.pdf

Star, J., Herbel-Eisenmann, B., & Smith, J. (2000). Algebraic Concepts: What's Really New in Curricula? *Mathematics Teaching in the Middle School*, 5 (7), p. 446-451.

Stiff, Lee V. (2001). Identifying *Standards*-Based Mathematics Materials. Available online at www.nctm.org/news/pastpresident/2001-10president.htm

Tennenbaum, Samuel (1951). William Heard Kilpatrick. New York: Harper & Brothers Publishers.

Thomas Jefferson Foundation (2004). Quotes by Thomas Jefferson available online at http://www.monticello.org/reports/quotes/education.html

Trafton, P., Reys, B., & Wasman, D. (2001). Standards-Based Mathematics Curriculum Materials: A Phrase in Search of a Definition. *Phi Delta Kappan*, 83 (3), 259-265.

U.S. Department of Education. Information related to No Child Left Behind available online at http://www.ed.gov/nclb/landing.jhtml and http://www.ed.gov/nclb/overview/intro/factsheet.html

Viadero, Debra (1999). A Direct Challenge. *Education Week*, March 17, 1999. Available online at http://www.edweek.org/ew/vol-18/27direct.h18

World Almanac Education Group Inc. (2003). 2003 World Almanac and Book of Facts. New York: World Almanac Books.

Wu, Hung-Hsi (1999). Basic Skills Versus Conceptual Understanding. *American Educator/American Federation of Teachers*, Fall 1999, 1-7. Available online at http://www.aft.org/publications/american_eduator/fall99/wu.pdf

Wu, Hung-Hsi (1997). The Mathematics Education Reform: Why You Should Be Concerned and What You Can Do. Available online at http://math.berkeley.edu/~wu

Zawojewski, J., Robinson, M. & Hoover, M. (1999). Reflections on Developing Formal Mathematics and the Connected Mathematics Project. *Mathematics Teaching in the Middle School*, 4 (5), 324-330.