THE IMPACT OF STANDARDS-BASED MATHEMATICS CURRICULUM ON MIDDLE SCHOOL STUDENTS' ACHIEVEMENT ON THE WESTEST

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ABSTRACT

Mathematics has become increasingly difficult for students to understand, make meaningful in their daily lives, and demonstrate competency in on standardized achievement tests. In attempt to remedy these situations, the National Council of Teachers of Mathematics developed a new way of delivering mathematical concepts called standards-based mathematics. It was the hope of this researcher to find a positive impact on student achievement on the mathematics portion of the WESTEST by middle school students who were taught in a standards-based classroom. This researcher described sixth, seventh, and eighth grade students' test scores from the 2004-2006 academic years in two suburban schools located in the northern panhandle of West Virginia, one this has developed a standards-based curriculum and one which teaches mathematics by use of a traditional curriculum.

Dedicated to my Mom and Dad

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CHAPTER 1

INTRODUCTION

Students have agonized over mathematics for decades, yet teachers continue to write two example problems on the board and assign a set of similar ones for students to practice hoping that this strategy will somehow breed deep understanding and appreciation of mathematics. With this teaching technique present in schools across the nation, it is not difficult to reason why the United States was so poorly represented in the Third International Mathematics and Science Study (Goldsmith and Mark, 1999). Recognizing this detrimental trend, the National Council of Teachers of Mathematics (NCTM) developed and revised a set of standards and curriculum in 1989, 1991, and 1995 called standards-based mathematics (Phillips, Lappan, and Grant, 2006). The goal of standards-based mathematics is to remedy students' fear, aversion, and misunderstanding of mathematics by providing instruction which instills lasting comprehension of concepts and processes; enhances students' ability to make connections within the content, other disciplines, and to everyday experiences; and finally generates students' capability of communicating mathematical ideas (Phillips et al. 2006).

Standards-based mathematics shows very little resemblance to a traditional mathematics classroom; therefore, administrators are often hesitant to try something so radically different, costly, and time consuming. Not only does the curriculum change, but the teachers must change as well. In Phillips et al. (2006) guide to implementing standards-based curriculum, the authors explain that a standards-based classroom environment should resemble a community working toward a common goal. Teachers of these classrooms are no longer deliverers of information but become facilitators of meaningful conversation. The key is to be able to ask the right questions of students so that they are challenged to the level of their individual capabilities. Students usually work in groups; therefore, the classroom environment may appear chaotic at times. Goldsmith and Mark describe a standards-based mathematics classroom as a busy environment where students are up gathering manipulatives to represent problems, engaging in heated debates with their teacher or peers, and covering their desks with materials to find various strategies for solving a problem (1999). Another major difference is that one problem may be studied for days or even weeks at a time in a standards-based classroom. Instead of covering one topic at a time, this curriculum incorporates several realms of mathematics into one lesson (Goldsmith and Mark, 1999). One final aspect of change arises in assessment. Instead of giving tests which ask students to regurgitate a memorized process, they are to write papers, complete projects, and record their thoughts and findings in journals (Phillips et al., 2006).

Years of practice, professional development, planning, and reflection are required to successfully implement a standards-based curriculum. The standards are achievable, but teachers must understand their rationale, be able to teach them in alignment with the state standards, and know how to use them in order to maximize their competence as teachers and students' potential (Janzen and Willoughby, 2005). Although the theory behind standards-based mathematics is that all students are able realize the importance of mathematics, understand its language, construct their own ideas, and come to class with a positive attitude, critics fear that the mastery of basic skills is being overlooked in this freedom-based environment (Goldsmith and Mark, 1999). If this is the case, this problem would surface in students' performance on standardized tests.

This study looked at the effect of a standards-based mathematics curriculum on middle school students' achievement on the statewide assessment given in West Virginia. The researcher gathered this information by obtaining student test scores between the 2004-2006 academic years from two schools located in a suburban county in the northern panhandle of West Virginia, one which has adopted a standards-based curriculum and the other which continues to teach traditional mathematics.

Statement of the Problem

Because standards-based mathematics is a current trend in education, there is very little research done to measure its effectiveness. The goal of this researcher was to be able to describe the impact standards-based mathematics curriculum has had on middle school students' performance on the West Virginia Educational Standards Test (WESTEST), a criterion-referenced test administered in grades 3-8 and 10.

Purpose Statement

The intent of this study was to show that standards-based mathematics does not retard students' ability to master rote mathematical skills or discriminate across socioeconomic and cognitive ability levels; rather, it enhances comprehension and retention of these concepts.

Research Questions

Do middle school students perform better on the WESTEST when taught in a standards-based mathematics classroom versus middle school students taught in a traditional curriculum?

Does standards-based curriculum affect middle school students' proficiency in basic mathematical skills?

Does standards-based mathematics discriminate against economically disadvantaged middle school students?

Does standards-based mathematics discriminate against middle school students with disabilities?

Research Hypothesis

It was the belief of this researcher that standards-based mathematics would have a positive impact on students' understanding of complex mathematics concepts without neglecting their learning of basic skills; therefore, it was anticipated that a standards-based mathematics curriculum would improve students' performance on the mathematics section of the WESTEST.

Null Hypothesis

There will be no difference in middle school students' performance on the mathematics section of the WESTEST who were taught with a standards-based mathematics curriculum.

Alternative Hypothesis

There will be a difference in middle school students' performance on the mathematics section of the WESTEST who were taught with a standards-based mathematics curriculum.

Limitations of the Study

As previously stated, standards-based mathematics goes much deeper than a changed curriculum. Merely because a school adopts the new curriculum does not mean that teachers are implementing it correctly. Furthermore, the schools in question had more than one teacher of middle school mathematics. Their experience and enthusiasm for the profession will differ, and in turn, affect student learning. Although the schools were from the same county, their contextual factors were not identical. The number of students eligible for free or reduced-priced lunch as well as the number students with an IEP or 504 plan differed between the schools affecting their composite mathematics scores.

Because this study only covers one school using a standards-based curriculum, the results found cannot be generalized to the entire population. Due to the recent development of standards-based mathematics, the curriculum adopted by this school is bound to have imperfections. A study of the effectiveness of the particular curriculum in question would enhance the reliability of this experiment. Additionally, it is unknown as to whether the WESTEST covers only the West Virginia content standards or if it incorporates the NCTM standards as well. This study will serve as an addition to the beginning of research being done on standards-based mathematics and provide an implication of the effectiveness of the recent shift in mathematics education.

CHAPTER TWO

LITERATURE REVIEW

With the focus on improved test scores growing each year, several research studies have been conducted in the last ten years to determine whether standards-based mathematics curriculum is affecting student performance on state and nationwide assessments. Experiments have been done to examine the effects of a reformed curriculum on elementary, middle, and high school aged students. Specifically, curriculum that has been studied includes the following: Mathscape (Ault, 2006), Everyday Mathematics (Carroll, 1997; Riordan and Noyce, 2001), Connected Mathematics (Riordan and Noyce, 2001), Interactive Mathematics Program and College Preparatory Mathematics (McCaffrey, Hamilton, Stecher, Klein, Bugliri, and Robyn, 2001), and the Core-Plus Mathematics Project (Huntley, Rasmussen, Villarubi, Sangtong, and Fey, 2000). Several researchers looked for correlations between specific mathematic tasks such as problem solving, number relations, and algebraic calculations (Ault, 2006; Huntley et al., 2000) while others studied the effects of standards-based mathematics on independent variables such as age, gender, socioeconomic status, race, and cognitive ability (Ault, 2006; Carroll, 1997; Riordan and Noyce, 2001). The results of these studies are widely varied; therefore, continued research in this field is essential before accurate conclusions can be determined.

Competency in Basic Operations

One of the biggest controversies surrounding standards-based mathematics is whether or not students are learning basic mathematical concepts and processes as well as they do in traditional mathematics. Carroll (1997) looked at the scores of third-grade students taught in a standards-based curriculum from 26 schools on the Illinois Goal Assessment Program (IGAP). The mean mathematics score in every school in this study was well above the state mean. Additionally, 382 students who had been in a standards-based classroom since kindergarten achieved significantly higher scores than the state mean on all six of the subtests. Carroll's results showed that these students attained the second highest gain in the area of number skills and concepts. This study confirms advocates' belief that a standards-based curriculum improves student test scores and refutes the opposition that it hinders their learning of basic concepts.

Another study, however, found just the opposite of Carroll's research. In Ault's study of student performance on the Ohio Sixth Grade Mathematics Proficiency Test, he found a significant difference between the students' mean score in the number relations sub-group (2006). Students taught with traditional mathematics outperformed those in a standards-based curriculum by 6.82 percent. Questions in the number relations section involved the computation of whole numbers, decimals, and fractions (Ault, 2006). Traditionally, these skills are taught with a series of drill and practice problems. Students spend weeks doing practice worksheets that might contain one to two word problems. With this much practice on basic skills, it is not surprising that students in a traditional curriculum are able to master these sections of standardized tests. Conversely, these skills are embedded in real-life scenarios that students work together to solve in a standards-based classroom; therefore, the number of problems practiced is considerably less than in a traditional classroom (Goldsmith and Mark, 1999). What needs to be considered here is which bears greater importance: that students are able to perform rote tasks that can be calculated instantaneously by technology or that they can identify which operation, along with how and why it will most appropriately allow them to solve a real-world problem.

A third study showed mixed results in performance between traditional and standards-based curriculum, this time in an area of higher order mathematical concepts. High school students involved in the Core-Plus Mathematics Project (CPMP) were taught algebraic concepts over a period of three years in which the curriculum was strictly standards-based emphasizing graphic, numeric, and symbolic problem-solving techniques. The researchers, Huntley et al. (2000), designed three assessments to test students' ability to transfer quantitative data into algebraic form, to use solutions of equations and inequalities to formulate new ideas, and to interpret and communicate an algebraic solution of a problem. The results of this study are in alignment with what most research is saying about standards-based mathematics. Students involved in the CPMP outperformed the control group in the areas of modeling quantitative relationships algebraically and interpreting results of calculations, but fell short by 30 percentage points when asked to substitute numeric values into equations or inequalities. Additionally, CPMP students were only able to outperform their counterparts when the use of graphing calculators was available. This research showed that students in a standards-based curriculum rely highly on context clues and technology when solving problems, but are able to set up models to solve problems and assess the validity of a solution by making meaningful connections to other contexts (Huntley et al., 2000).

Concerns of Discrimination

Further accusations have been made against standards-based mathematics claiming that it poses increased disadvantages on students of various ethnic and racial backgrounds, those coming from families of a low socioeconomic status, and those who are cognitively delayed (Goldsmith and Mark, 1999). In 2001 Riordan and Noyce's study of fourth and eighth grade student achievement on the Massachusetts Educational Assessment Program (MEAP) reported that "the positive impact of the standards-based programs on student performance was remarkably consistent across students of different gender, race, and economic status." Additionally, students of all intelligence levels scored better on the MEAP than their counterparts in a traditional curriculum (Riordan and Noyce, 2001). The MEAP assesses students in number sense, patterns and functions, geometry, and statistics via a series of multiple choice, short answer, and open response questions. Fourth-grade students in the reformed curriculum outperformed their comparison group not only in the open response questions as expected, but in the short answer and multiple choice categories as well. The same was true for eighth-grade students with the exception of the short answer section (Riordan and Noyce, 2001). When standards-based curriculum is implemented correctly, it should not come as a surprise that it does not hinder the performance of students with varying demographics. Standards-based mathematics leaves open the opportunity for differentiated instruction in more ways than any other teaching technique. Because students work in groups to solve problems, teachers can assign them roles of the investigation that best match their individual needs (Phillips et al., 2006).

Further studies report findings that contest the claim that standards-based mathematics poses an obvious disadvantage to some students. In the study by Carroll (1997) discussed previously which compared student performance on the IGAP, out of 26 schools in the study, the 3 with the highest percentages of low-income populations scored well above the mean score in the study, the state's mean, and the mean of the wealthiest county in Illinois using traditional mathematics. Outstandingly, only 2% of students did not meet the state goal, which Carroll translated into less than one student per classroom, much less than the number in each classroom of low-income students. One final study conducted by Ginsburg-Block and Fantuzzo (1998) also looked for correlations between standards-based mathematics curriculum and the achievement of urban students living in poverty. Third and fourth-graders in this study were chosen by results on a curriculum-based pretest with those scoring in the lower half of their class being asked to participate in the study. All students in the school where the study was conducted came from low socioeconomic families with 67% of them living below the poverty line. Sixty-eight percent of the students in this study were African American and all of them qualified for free or reduced-priced lunch. This treatment group was given the opportunity to attend two half-hour standards-based mathematics sessions weekly for seven weeks and then was post-tested. Students in this study showed significant gains in academic achievement, motivation, and social as well as academic self-concept (Ginsburg-Block and Fantuzzo, 1998). This study serves as a reminder that one of the greatest goals of standards-based mathematics is to improve students' outlook of mathematics in general and especially the perception of their individual mathematic abilities.

Limitations of Research Results

Factors that need to be considered when analyzing the results of these experimental studies are teachers' years of experience, enthusiasm, and professional development, in addition to the number of years that the students in question have been involved in a reform-based curriculum. None of the studies examined formally accounted for teacher qualifications, but some did look at the duration students have learned in a standards-based classroom. Carroll's (1997) study of third-graders showed that the students from schools who had adopted the curriculum since they were in kindergarten showed more significant gains than those who were in the curriculum for only one or two years. Fifty-four percent of these students met the state goals while 42% showed substantial gains from the previous year (Carroll, 1997). In congruence with these findings, Riordan and Noyce (2001) discovered also that both the fourth and eighth grade students in their study made greater progress when taught with a standards-based curriculum for two or more consecutive years. Teachers, as students, become better with practice. As one study showed, there is a positive relationship between the amount and degree to which teachers report using standards-based techniques in their classroom and student achievement (McCaffrey et al., 2001). These results suggest that not only are students adjusting to the new curriculum, but teachers are improving their implementation techniques as well. Planning, grading, and assessment are only a few of the many aspects of the profession which drastically change in a standards-based classroom. For this reason, it is unreasonable to make judgments of its effectiveness at such an early stage in its on-going development.

Factors Affecting Implementation

Researchers have found that merely changing the curriculum or teaching environment will not spark the benefits of standards-based mathematics. It would make sense that, because standards-based instruction is more involved, problems have greater depth, and students are highly active in the classroom, that a block schedule would give teachers the opportunity to really make it effective; however, Flynn, Lawrenz, and Schultz (2005) found that this idea is far from reality. In their study of middle school teachers, survey results showed that teaching techniques supported by the NCTM were used no more regularly in a block schedule versus a traditional one (Flynn et al., 2005). In another study, researchers say that using problem-based learning is only effective if the problems are well-designed and well-sequenced (Murray, Olivier, and Human, 1998). These researchers also cautioned schools to be aware of community concerns when changing curriculum. With a technique that calls for a great amount of communication, members of the ESL population, in particular, will be apprehensive to support such a change (Murray et al., 1998). In Phillips et al. (2006) guide to implementing standards-based curricula, they suggest that parents be fully informed of the nature and implications of a change in curriculum before it takes place. Regular communication with parents is more crucial than ever because they may not have the resources available at home to help their children or may become easily frustrated when they do not understand a problem or assignment (Phillips et al., 2006). With the information collected by researchers, it is clear that mathematics education has many barriers to cross before successfully meeting the goals of NCTM.

CHAPTER THREE

METHODS

Study Design

In this descriptive study, the researcher compared the scores of two groups of middle school students in the 2004-2006 school years on the mathematics section of the WESTEST. Quantitative methods were used to analyze student performance. Public data published on the WESTEST Assessment website was used to gather information because individual score reports could not be obtained. Reports are posted of all West Virginia schools and include composite means broken into the categories of gender, race/ethnicity, students with disabilities, limited English proficiency, migrant, and economically disadvantaged students. Furthermore, mean scores are given in each of the content standards evaluated on the test. Score reports were examined by this researcher of two sets of students in grades 6-8 from different schools in the 2004, 2005, and 2006 school years, one which uses a traditional curriculum and the other entirely standards-based.

Instruments

The WESTEST was used to determine the effectiveness of standards-based mathematics on these students because it is a standardized, criterion-referenced test directly aligned with the West Virginia Content Standard Objectives (WESTEST Assessment Office, 2007). As previously stated, NCTM claims that the objectives covered in a standards-based curriculum meet the state standards as effectively as a traditional curriculum with added benefits (Goldsmith and Mark, 1999). In grades 3-8, the WESTEST contains 52 mathematics items: 48 multiple-choice and 4 open-response questions. Students are only permitted to use a calculator on the 4 open-response items. Neither portion of the test is timed. The five subcategories the WESTEST covers include the following: number/operations, algebra, geometry, measurement, and data analysis/probability (WESTEST Assessment Office, 2007).

Table 1. Percentage of Questions Devoted to Each Subcategory by Grade Level

	Grade 6	Grade 7	Grade 8
Number/Operations	26	23	18
Algebra	26	26	30
Geometry	19	15	18
Measurement	15	16	14
Data Analysis/Probability	14	20	20

The objectives covered by the WESTEST are categorized into depth-of-knowledge levels ranging from 1 to 4 with level 1 being recall, level 2 skill/concept, level 3 strategic thinking, and level 4 extended thinking. These depth-of-knowledge levels have been carefully calculated and vary accordingly for each grade. All of the objectives tested in grades 6-8 fall within the level 1, 2, or 3 ranges (WESTEST Assessment Office, 2007).

Likewise, the five books used in the *Connected Mathematics* series cover the areas of number/operations, algebra, geometry, measurement, and data analysis/probability. Students work through the problems one book at a time in the order stated. Each book contains problem solving, reasoning and proof, communication, connections, and representation tactics (Connected Mathematics Project, 2006).

The reliability and validity of both the WESTEST and the Connected Mathematics Project (CMP) are continually being assessed through field testing. In 2003, Dr. Norman Webb of the Wisconsin Center for Education Research conducted an independent and external alignment study to gather evidence of the WESTEST's content and construct validity (WESTEST Assessment Office, 2007). Results of this study showed that there was a strong alignment with the West Virginia Content Standard Objectives in the mathematics portion of the test (WESTEST Assessment Office, 2007). In creating the *Connected Mathematics* curriculum, the following four steps were taken to prove its validity: commissioning reviews from experts, using a field-trials feedback loop for the materials, conducting classroom observations by the CMP team, and monitoring student performance on state and local tests by trial schools. This process takes five years to complete and is followed by the publisher's final revisions (Connected Mathematics Project, 2006).

Setting and Population

The schools used in this study are from a mid-size county in the northern panhandle of West Virginia. The city they are located in has a population of approximately 32,000 people. Both schools are nestled in the residential suburbs of the larger city. School A uses the *Connected Mathematics* curriculum in grades 6-8 whereas School B uses a traditional mathematics textbook series. According to the National Center for Education Statistics, during the 2005-2006 school year, School A had 528 students in grades PK-8 with a student/teacher ratio of 14.8 while School B had 442 students in grades 6-8 with a student/teacher ratio of 13.6; however, School A had 60 sixth-grade students, 71 seventh-grade students, and 86 eighth-grade students whereas School B had 144, 151, and 147, respectively. Both schools have a predominately Caucasian population with the largest minority group being African American. In School A, 220 students were eligible for free or reduced-priced lunch with 200 being eligible in School B. Neither school is allotted Title I funding. School A has 1 male and 2 female teachers of 6-8 mathematics while School B employs 2 male and 3 female teachers due to its increased number of students.

Ethical Issues

Prior to the conduction of this study, the researcher gained permission from the Marietta College Human Subjects Review Board. Individual teacher class scores will not be reported; rather, the entire sixth, seventh, and eighth grade classes will be studied as a whole. The names of individual students will not be used at any point in this study. This study is not being used to compare school performance, but the effectiveness of a specific curriculum. Judgments will not be made on overall teacher or school success. The intent of this study has no underlying meaning: it will merely be used to add to the body of research concerning the recent push for standards-based mathematics. The researcher will be careful to preserve this purpose throughout the study and reporting of results.

CHAPTER FOUR

RESULTS

Composite Mathematics Scores

In analyzing the composite mathematics score reports for both the standards-based and traditional curriculum schools, there does not appear to be an obvious difference at first glance. Although the scores are close, the standards-based students outperformed the traditional students in 6 of the 9 data points collected. What is most interesting about this set of records, however, is the increase in the percentage of students at or above mastery level from the 2004 to 2006 years in the standards-based school. The lowest percentage of students at or above mastery level occurs in 2004 with a 74%, and the highest percentage of students at or above mastery level occurs in 2006 with a 92%. On the other hand, the maximum percentage of students at or above mastery level in traditional mathematics occurs in 2005 at only 85%. These results can be seen in Table 2 below.

Table 2. 2004-2006 Composite Mathematics Scores

	6th,04	**7th,04**	**8th,04**	**6th,05**	**7th,05**	**8th,05**	**6th,06**	**7th,06**	**8th,06**
SBM	80	74	78	87	87	82	92	90	84
TM	79	78	78	85	79	85	81	81	83

Students with Disabilities

Scores are only reported if a subgroup contains 10 or more students; therefore, only three data points could be compared among the students with disabilities. In each of these groups, there were considerably more students at or above mastery level in the standards-based curriculum. In 2004, 2 out of 10 seventh-grade students who took the test scored at or above mastery in the standards-based curriculum while only 2 of 15 seventh-grade students tested did so in the traditional curriculum. In 2005, the results were 5 out of 10 seventh-grade students in standards-based and 6 out of 19 in traditional. In 2006, 5 out of 11 eighth-grade students in standards-based scored at or above mastery level while 4 out of 13 eighth-grade students did so in the traditional curriculum. These results are summarized in Table 3.

Table 3. Students with Disabilities

	7th,04	**7th,05**	**8th,06**
SBM	20	50	45
TM	13	32	31

Economically Disadvantaged Students

The results do not favor either the standards-based or traditional curriculum within the subgroup of economically disadvantaged students. Of the 9 data points compared, the standards-based students outperformed the traditional students in 5 of them. In 4 of these 5 cases, however, the percentage difference between the number of students who achieved mastery or above on the test was at least 10 rising as high as a 31 percentage point difference. It is also interesting to note that the range of percentages of students at mastery or above in the standards-based curriculum goes from 59 to 100, whereas the range in the traditional curriculum is only from 56 to 69. Furthermore, the standards-based students lowest percentage occurred in 2004 while their highest, 100%, happened in 2006. Because standards-based textbooks require more reading in mathematics than a traditional curriculum does, it is necessary for teachers to be sure students comprehend the problems before accurate judgments can be made of its effectiveness. This factor alone may contribute to the majority of past researchers negative results of standards-based mathematics in this subgroup. These percentages are presented in Table 4

Table 4. Economically Disadvantaged Students

	6th,04	**7th,04**	**8th,04**	**6th,05**	**7th,05**	**8th,05**	**6th,06**	**7th,06**	**8th,06**
SBM	64	59	69	85	79	67	100	90	72
TM	70	64	56	75	71	73	69	68	74

Number and Operations Subgroup

There are very few patterns which can be identified in the data points compared within the number and operations subgroup. Of the 9 entries collected, the standards-based students outperformed the traditional students in 6 of them. However, the difference in these percentages was 5 or less in all cases but 1 in which the difference was 11 percentage points. Continuing the theory that standards-based mathematics has a longitudinal effect on students' performance, it should be recognized that in all three groups in 2006, the standards-based students outperformed the traditional students. This year is also where the 11 percentage point gap occurred. Table 5 below summarizes this data.

Table 5. Number and Operations Subgroup

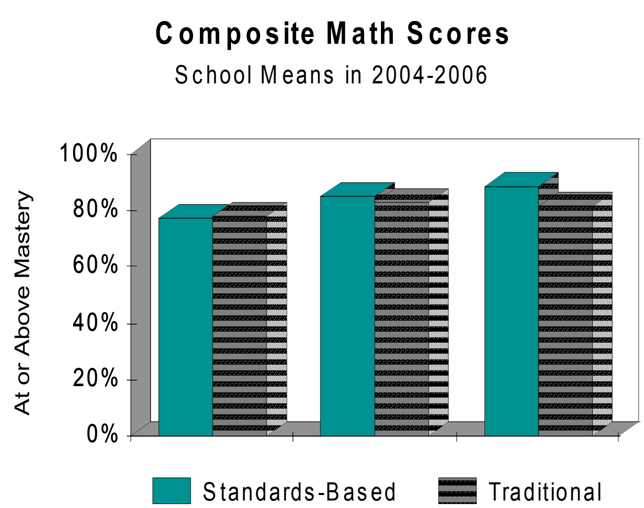
	6th,04	**7th,04**	**8th,04**	**6th,05**	**7th,05**	**8th,05**	**6th,06**	**7th,06**	**8th,06**
SBM	76	70	82	83	79	81	80	89	79
TM	77	75	81	80	76	83	76	78	78

CHAPTER FIVE

SUMMARY/CONCLUSION

By analysis of the composite mathematics scores in grades 6-8 in the 2004-2006 school years, this researcher believes that there are not enough differences in the scores between the standards-based and traditional students to claim that one curriculum is more effective than the other. As previously discussed, in several studies a positive longitudinal effect took place in many schools using a standards-based curriculum. The results found in this study portray that a standards-based curriculum may be having the same effect on School A as well. In School A, the average percentage of students at or above mastery on the mathematics portion of the WESTEST in grades 6-8 from 2004-2006 are 77.3%, 85.3%, and 88.6%, respectively. In School B, the corresponding data is 78.3%, 83%, and 81.6%. These numbers are represented in the following figure:

Figure 1. Composite Scores by Year



What can be seen in this figure is the constant gain in the percentage of students at or above mastery level in the standards-based curriculum. There does not exist, however, a great difference in these numbers compared to those in the traditional curriculum. If standards-based mathematics was having a significant positive effect on students' comprehension of mathematics, there should be a greater difference between these two sets of data. As stated previously, the objectives of the standards-based curriculum directly align with the objectives measured by the WESTEST, but these results have shown that it is possible to cover these objectives as thoroughly using traditional mathematics. Because a longitudinal effect may be occurring in the standards-based school, it would be interesting to compare the results in the 2007-2009 academic years. Based on the data collected, the traditional school will hover around the 80% mark while the standards-based school will have 90% or more of their students achieving mastery or above on the assessment.

Discrimination Claims Denied

The results of this study show that there are no signs that standards-based mathematics discriminates against students with disabilities or those economically disadvantaged. It does, however, show that these groups of students produce significantly higher scores on the WESTEST than those in a traditional curriculum. The data points analyzed in the economically disadvantaged subgroup also suggests longitudinal improvement in the standards-based school. The average number of students at or above mastery in 2004 grew from 64% to 87.3% in 2006. Conversely, these numbers fell from 70% in 2004 to 68% in 2006 in the traditional school. The large difference in these percentages can be attributed to several factors. As the developers of standards-based mathematics advertise, this type of instruction may be more appealing to students particularly from a low-income home. Students in this environment usually prefer the hands-on instruction that standards-based curriculum promotes. They come from families where working together especially with siblings and peers is the norm. Numbers and symbols have much less relevance to them than real-world situations. These kids are natural problem-solvers and tend to be successful at being realistic. The same is true for students with disabilities. Given 20 problems to solve quietly versus a set of manipulatives to build a representation of the same concept, almost always, their minds will shut down after the first problem, but they will work hours on perfecting something they built with their own hands. They need to be able to see, touch, and create. With the right method of instruction, both groups of students have the potential to fascinate a teacher by their knowledge and appreciation of mathematics. Experts, research, and this study all indicate that standards-based mathematics is the bridge between fear of mathematics and a powerful understanding of it.

Basic Mathematic Skills

Opponents of standards-based mathematics are most concerned that it hinders students' ability to perform basic mathematical operations. These skills are tested in the number and operations section of the WESTEST; therefore, the results of that subgroup were analyzed apart from the test as a whole to determine if the standards-based students in School A fell short to the students in School B using a traditional curriculum. Specifically, the skills in question are organized below in an outline taken directly from the *Connected Mathematics* website.

Number and Operation Goals

Number Sense

- Use numbers in various forms to solve problems (6, 7, 8)
- Understand and use large numbers, including in exponential and scientific notation (6, 7, 8)
- Reason proportionally in a variety of contexts using geometric and numerical reasoning, including scaling and solving proportions (6, 7, 8)
- Compare numbers in a variety of ways, including differences, rates, ratios, and percents and choose when each comparison is appropriate (6, 7, 8)
- Order positive and/or negative rational numbers (6, 7, 8)
- Express rational numbers in equivalent forms (6)
- Make estimates and use benchmarks (6, 7, 8)

Operations and Algorithms

- Develop understanding and skill with all four arithmetic operations on fractions and decimals (6)
- Develop understanding and skill in solving a variety of percent problems (6)
- Use the order of operations to write, evaluate, and simplify numerical expressions (7, 8)
- Develop fluency with paper and pencil computation, calculator use, mental calculation, estimation; and choose among these when solving problems (6, 7)

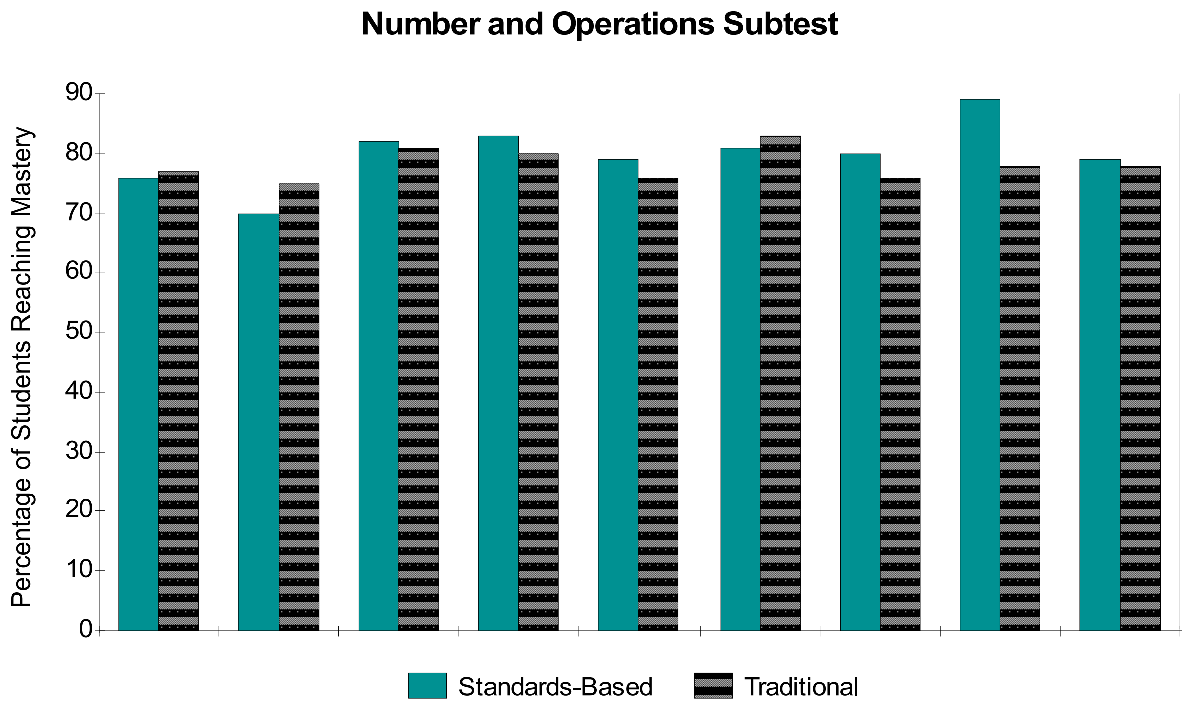
Properties

- Understand the multiplicative structure of numbers, including the concepts of prime and composite numbers, evens, odds, and prime factorizations (6)
- Use the commutative and distributive properties to write equivalent numerical expressions (7, 8)

(Connected Mathematics Project, 2006)

The developers of this standards-based curriculum attest that these concepts are aligned with the NCTM Standards and state objectives. If this is in fact true, there should be no surprise concepts occurring on the WESTEST that standards-based students have not seen. Still, critics argue that because standards-based mathematics does not require an ample amount of practice problems on these basic skills that students do not understand them as well as they should. The developers of standards-based mathematics believe that these concepts are imbedded continuously throughout the entire curriculum allowing students to have an equal opportunity to master the skills without drill and practice (Goldsmith and Mark, 1999). The results of this researcher's analysis of the percentage of students at or above mastery level on the number and operations subtest in a standards-based and traditional curriculum are shown in Figure 2.

Figure 2. Means on the Number and Operations Subtest



Looking at the results of this comparison as they are presented in Table 2, this researcher sees no strong evidence that students in a standards-based curriculum are not exposed with enough material to perform basic mathematical operations as well as students learning by a traditional curriculum. The content of this portion of the WESTEST can be memorized or it can be learned. Done successfully, either method would produce similar scores as they have in this study. From this test, it is impossible to tell which group of students will still be able to perform basic mathematical tasks with this accuracy after not having a math class for several years. It would be interesting to retest these groups of students in 10 years and find who retained more knowledge of mathematics. Memorized processes are only retained if they are accessed often; therefore, this researcher believes the standard-based students would significantly outperform the traditional students in a future retest. In these test results, there is not a great enough difference in the students' scores on the number and operations subtest to convict standards-based mathematics of neglecting basic mathematical operations in its curriculum.

Future Implications

Although the standards-based curriculum, *Connected Mathematics,* does not appear to have had a significant impact on middle school students' overall achievement on the WESTEST, it has not had an alarming negative effect on their achievement either. In each of the four categories analyzed from the score reports collected, a positive longitudinal effect is forming; therefore, reverting back to a traditional curriculum would be illogical in this school. Change does not lead to overnight progress. This standards-based curriculum has shown great positive impact on economically disadvantaged and disabled students and has not delayed overall comprehension of basic operations.

As with many other studies of standards-based mathematics, this analysis did not lead to any definite conclusions on the strategies' effectiveness on student learning. A change in curriculum without the cooperation and enthusiasm from teachers will rarely improve a students' performance. This researcher believes that the difference in the quality of teaching is the cause for such mixed results in the determination of the impact of standards-based mathematics. The theory behind this "revolutionary" teaching strategy has been around since the days of Horace Mann. In 1840, he wrote, "the mind of a teacher should migrate, as it were, into those of his pupils, to discover what they know and feel and need; and then, supplying from his own stock, what they require, he should reduce it to such a form, and bring it within such a distance, that they can reach out and seize and appropriate it" (Mann, 1840). Research has shown in all subject areas that by giving students choice, bringing what is taught in the classroom to real life, and helping them realize the significance of education will increase learning and comprehension. These are difficult tasks; hence, the necessity for driven, qualified, and compensated teachers.

It seems as though America has receded in its ability to understand students' needs and then rediscovered its knowledge in the 21st Century. It makes perfect sense that a boring, drill and practice textbook will not ignite a student's desire to learn. Standards-based materials provide the problems students need to get excited about learning math. Teachers need to let go of their set ways, lost hopes, and quick judgments to rediscover the genius and beauty of mathematics with their students. Standards-based mathematics has set the pathway for this to occur. Without question, teachers can create a new generation of students who love and appreciate mathematics and the world of opportunities it has to offer. The reality is whether or not the United States is prepared to perfect this new curriculum and compete with those who have long ago discovered it.

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