Investigation Mathematics in Public Schools

A Special Project

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ABSTRACT

The purpose of the study was to determine if the implementation of the *Investigation* mathematics curriculum in schools improved student scores on the Washington Assessment of Student Learning. Out of over one hundred fifth grade students, twenty-five students were chosen at random for the study. The students were given the Washington Assessment of Student Learning in April 2006 and April 2007. During this time, the students were given direct instruction in the *Investigation* curriculum. The scores were collected and analyzed to determine if the students had made growth on the mathematics portion of the Washington Assessment of Students Learning.

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CHAPTER 1

Introduction

Background for the Project

Standards-based mathematics was one name for a reform method of mathematics instruction, based on recommendations published in 1989 by the National Council of Teachers of Mathematics (1989). The original document was titled, “Principles and Standards for School Mathematics,” which attempted to set forth a North American vision for precollege mathematics education in the United States and Canada. The recommendations were largely adopted by most education agencies, from the local to the federal levels, by the mid 2000s. This was the primary basis for most states’ mathematics standards, for many federally funded textbook projects, and for the influence on standards in other nations.

The major goal of standards-based education was to ensure that all children would succeed by setting uniform standards of what every child was expected to know and be able to do. Public schools held all participants in the system accountable through standards and assessments. The standards-based movement intended to have all students master the mathematics skill-set adopted by the education agency.

School districts believed there was reliable evidence that changing curriculum materials could alter classroom instruction. Curriculum materials provided the activities that shaped the daily interactions between students and teachers.

Statement of the Problem

The National Science Foundation was spending millions to promote implementation of the Technical Education Research Centers or TERC program, *Investigations in Number, Data and Space.* Local school boards were easily persuaded to adopt this new curriculum. Publishers claimed the program moved beyond arithmetic to offer significant mathematics that included important ideas that ranged from probability, statistics, 3-D geometry, and number theory. But the researchers believed mathematics was a vertically-structured knowledge domain and learning more advanced mathematics was not possible without first mastering traditional pencil-and-paper arithmetic (Scott, 2006).

The mathematics curricula adopted by the author's elementary school and many other school districts were among the more extreme of the standards-based curricula. The *Investigation in Number Sense, Data and Space* curriculum included time-consuming hands-on activities that involved scissors and glue, group discovery and Connected Mathematics Project. Through the use of suggestion, teachers allowed the students to bump into the answer. Traditional algorithms, such as addition and subtraction (borrowing and carrying), long division, or addition of more difficult fractions were not explicitly taught, preferring students to find answers through discovery. Some teachers chose to teach standard algorithms, although this was not encouraged by acclaimed national mathematics activist organizations. *Mathematically Correct* reviewed a number of mathematics curricula based on eight different elementary and eleven different pre-algebra programs (Roberts, 2005). Of the programs reviewed, *Investigations* and Connected Mathematics Project had the worst ratings.

A problem the elementary school in eastern Washington encountered when it adopted and implemented *Investigations* was that students' scores dramatically dropped on the Washington Assessment of Student Learning. Student's mathematics scores were dropping not only on the Washington Assessment of Student Learning but in class as well. The author wanted to determine if the decrease in scores was due to the implementation of the mathematics program *Investigations* adopted in the chosen elementary school.

<u>Purpose of the Project</u>

The purpose of this project was to examine the new mathematic curriculum *Investigations* in schools state wide and determine if it made a significant difference in WASL scores. Researchers spoke of a need for higher-order thinking, conceptual understanding, and solving problems, but *Investigations* publishers neglected to acknowledge the systematic mastery of the fundamental building blocks necessary for success in any of these areas. Publishers focused on strategies that used calculators, blocks, guesswork, group activities and shunned strategies that taught algorithms and encouraged repeated practice.

Delimitations

In October 2005 there were 528 students enrolled in grades K-5 in the elementary school that was the focus of this study. The ethnicity of the elementary school was broken down into 60% white, 31.1% Hispanic, 3.6% Black, 3.6% Asian and 1.5% American Indian/Alaskan Native. In May 2006, 32.3% of the student population received free or reduced-price meals and 13% were receiving Special Education services (OSPI, 2005).

In October 2006 there were 604 students enrolled in grades K-5 in the elementary school, an overall growth of 76 students from the previous year. The ethnicity of the elementary school was impacted. It was now 57.3% white, 35.4% Hispanic, 2.6% black, 3.3% Asian and 1.0% American Indian/Alaskan Native. In May 2007, 39.4% received free or reduced price meals and 14.5% were receiving Special Education Services (OSPI, 2006).

Assumptions

All students in the study received equal amounts of instructional time with the *Investigations* mathematics curriculum. Students received only *IN* instruction in the classroom and teachers were not allowed to supplement *IN* materials.

Hypothesis

Students who received *Investigations* Mathematics instruction would show significant growth as measured by the Washington Assessment of Student Learning.

Null Hypothesis

Students who received *Investigations* Mathematics instruction would not show significant growth as measured by the Washington Assessment of Student Learning.

Significance of the Project

Although *Investigations* was initially a commercial success, federal programs helped pay for a widespread adoption without a formal public debate process. An increasing number of educational institutions discarded the program as an instructional failure because it was nearly always supplemented with traditional mathematics materials. This was necessary because, in line with controversial studies which claimed it harmful to teach standard arithmetic to elementary school children, *Investigations* did not teach any traditional arithmetic methods familiar in other states, or familiar to parents, especially those with limited education. This created a serious problem.

The goal of the program was to help all children understand the fundamental ideas of number arithmetic, geometry, data, measurement and early algebra. Many of the concepts were unfamiliar not only to parents, but also to professional mathematicians who had never seen such an approach to mathematics before. As with other standards-based curricula, *Investigations* was distinguished by the complete lack of presentation of any traditional computing methods, and a lack of congruence with any other standards-based mathematics series, which were all developed using completely different alternative approaches to computation. If the *Investigation* program was not improving student growth and improving test scores, then a new program needed to be implemented or *Investigations* needed to be supplemented.

Procedure

During the school year the *Investigation* program had been the only mathematics curriculum taught to the students in the school. The author collected random students' scores from the Washington Assessment of Student Learning in mathematics from the building. The author wanted to see if there was an increase in scores since *Investigations* was adopted.

Definition of Terms

Essential Academic Learning Requirements: Washington learning standards provided an overview of what students should know and be able to do in grades K-10.

Investigations in Number, Data and Space: *Investigations* was a complete K-5 mathematics curriculum designed to help all children understand the fundamental ideas of number and operations, geometry, data, measurement and early algebra.

Washington Assessment of Students Learning: The Washington Assessment of Student Learning measured students learning of the state's academic standards. Students were tested each spring in grades 3-8 and 10 in reading and mathematics. Students were also tested in writing in grades 4, 7 and 10 and science in grades 5, 8 and 10.

Acronyms

EALR Essential Academic Learning Requirements

IN Investigations in Number, Data and Space

NCTM National Council of Teachers of Mathematics

NSF National Science Foundation

TERC Technical Education Research Center

WASL Washington Assessment of Student Learning

CHAPTER 2

Review of Selected Literature

Introduction

Literature selections reviewed for the study dealt primarily with the history of *IN*, EALR requirements for passing the mathematics portions of the WASL, and how the *IN* curriculum was not aligned with the GLEs and EALRs.

The major themes found in the areas of choice were: 1. History of *IN* Mathematics, 2. EALR requirements in Mathematics, and 3. Curriculum Alignment with the EALR/GLEs.

Investigation Mathematics

The literature on *IN* focused primarily on the history of the *IN* and the current supporters. During the 1980s, standards-based mathematics was set forth in the United States and Canada by the NCTM. In 1986, the NSF funded TERC to develop *Used Numbers*, teaching units that focused on data analysis in K-6. Later, funding from the California Department of Education supported the development of a replacement unit called *Seeing Fractions.* Then, in 1990, NSF funded TERC and developed a coherent K-5 mathematics curriculum, the first edition of *Investigation in Number, Data and Space.*

Investigation in Number, Data and Space was defined as: "a complete K-5 mathematics curriculum designed to help all children understand the fundamental ideas of number and operations, geometry, data, measurement and early algebra" (Quirk, 2007, p. 9). The mathematics curriculum was developed by TERC, with funding from the National Science Foundation (NSF). The NSF spent millions to promote implementation of the TERC program. School boards found it difficult to say no. They rationalized, "It's just a different way to teach elementary mathematics, and the NSF backs it, so how hard can it be?" (Wilson, 2005, p. 5).

Investigations was a reform mathematics curriculum. "Mathematics achievement in America is far below what we would like it to be. Recent reform efforts only aggravate the problem. As a result, our children have less and less exposure to rigorous, content-rich mathematics" (*Teach*, 2005, p. 15). Many parents were led to believe that *Investigations* taught higher order thinking skills. "Concerned parents are in a state of dismay and have begun efforts to restore content, rigor and genuinely high expectations to mathematics education" (Bell, 2006, p. 256). But TERC believed that mathematics was a vertically-structured knowledge domain. "Learning more advanced mathematics isn't possible without first mastering traditional pencil-and-paper arithmetic" (Wilson, 2005, p. 6). The truth was clearly demonstrated by the shallow details of the TERC fifth grade program. "Their most advanced *Investigations* offer probability without multiplying fractions, statistics without the arithmetic mean, 3-D geometry without formulas for volume, and number theory without prime numbers" (Quirk, 2007, p. 11).

The State of Washington quickly embraced this new mathematics which some referred to as fuzzy mathematics that exacerbated the disturbing trend. At the grade school level new mathematics was characterized by the mathematics curriculum called *Investigations* which had already been adopted by many districts within the state. These mathematics books were almost devoid of numbers. The curriculum eliminated the standard computational methods, standard formulas, and standard technology. Only the simplest fractions were examined, because simple fractions were the only ones that could be represented in pictures. *Investigations* replaced the traditional curriculum rather than augmenting it. In addition, students were supposed to invent their own computational methods, but few elementary school teachers had the ability to coach students on testing their methods for correctness or generality. That aspect of the curriculum guaranteed that a student would not be ready for higher level mathematics in high school.

One local expert had suggested that a minimum of three to five years of additional training was required to get the average elementary school teacher to a point where he or she could start to expect some positive results using *Investigations*. "Should we allow our children to be guinea pigs while districts look for the funds and teachers struggle to find the extra time to get extra training?" (Shapire, 2006, p. 1).

> The mathematics curriculum currently in fashion-*Investigations*- just doesn't work. It is a stupid way to teach mathematics and it is largely responsible for the poor results we see on standardized tests. How many years of low scores will it take before the people who choose curricula figure out that this one isn't working? How much data do they need? (Russell, 2008)

<u>WASL Requirements in Mathematics</u>

The Washington Assessment of Student Learning (WASL) was a standard-based assessment. This test measured student performance against a broad set of standards, the Essential Academic Learning Requirements (EALR). The EALRs spanned a broad spectrum of curriculum content and processed strands, across all grade levels, K-10. The WASL was merely a measurement of student progress toward meeting those standards. As such, WASL was not a test that lent itself to increased achievement through cramming or short term focus on particular content. Improved performance on the WASL came from the concerted effort of aligning curriculum and instruction practice with research and the standards against which performance was measured.

<u>Curriculum Alignment with EALRs/GLEs</u>

A major problem with the *Investigations* mathematics program, according to many parents and educators, was that it was not aligned with the EALRs. That alignment problem was believed by many educators to be the cause of the dropped scores on state wide tests.

In January 2006, OSPI posted a report from the Washington State Instructional Materials that stated Investigations K-5 was only forty-nine percent aligned with Washington's EALRs, which left over half of the mathematics curriculum poorly aligned or not in alignment at all. The researcher looked at third grade and fourth grade alignments and which were even lower. Only forty-three percent were aligned with Washington's EALRs and GLEs in the third grade and a mere forty percent were aligned in the fourth grade (see Table 3).

The fourth grade mathematics EALRs stated:

> Apply strategies, and use tools appropriate to tasks involving multiplication and division of whole numbers…Strategies give the impression that multiplication and division problems are ad hoc problems. They are not. They are standard procedures, algorithms that work every time. Yet no where are students asked to memorize basic algorithms in this curriculum. These algorithms should be taught and listed as explicit standards. (OSPI, 2006)

<u>Summary</u>

The literature surrounding education reform showed how education had progressed to present day. Many changes, whether national movements or state movements, helped make high-stakes testing become a way of life in the educational world. Adoption of a new mathematics curriculum in many schools statewide has made it hard for students to pass state assessments because there was no alignment between the state assessments, standards, and EALRs.

Due to these high stakes standards, teachers have been frustrated with the new mathematic curriculum *IN*. Teachers have had to dig deep to find new and unique ways to teach the adopted curriculum and help the students pass the WASL. The challenge has been to teach the *IN* curriculum because it was the adopted curriculum in the district, and still prepare students for the mathematics portion of the WASL, which required teachers to supplement and extend mathematics time in classrooms.

CHAPTER 3

Methodology and Treatment of Data

Introduction

In 2007, twenty-five students' were randomly selected from the author's school to determine if the *IN* curriculum improved mathematics scores on the WASL. During 2005-2006 school year and again in the 2006-2007 school year, all students in the chosen elementary school received instruction using the *IN* curriculum for mathematics. The students were then given the WASL in the spring of 2006 and again in the spring of 2007. The scores were then compared to determine significance.

Methodology

The author randomly picked twenty-five students and compared the student's mathematics WASL scores from the spring of 2006 to the student's mathematics WASL scores from the spring of 2007. To accomplish this task, a quantitative approach was used. Specific testing was not necessary to answer the author's questions as test data was already available. The students' scores were entered into the STATPAK (2007) computer program using a t-test to determine if students made significant growth on the mathematics portion of the WASL (Gay, Mills, & Airasian, 2003).

Participants

The twenty-five randomly chosen student participants came from a large Washington state school district in Eastern Washington. Of the students, ten were from middle socio-economic Caucasian families, eleven were from middle socio-economic Hispanic families and four were from lower socio-economic Caucasian families. Five of the students came from homes with one parent working while the other was a stay home parent, ten of the students came from homes with two working parents, and the rest came from single parent homes where the parent worked one or more jobs to support the family.

Instruments

The WASL assessment was given to the twenty-five students in the spring of 2006 and spring of 2007. The OSPI recorded the data and placed the data in an organized report for easy viewing. Scores were viewable on the OSPI website and a copy of all scores was sent to the school's administration for quick viewing. The mathematics WASL scores were gathered, organized in a table, and analyzed using the STATPAK (2007) computer program.

Design

Randomly selected student's WASL scores from both spring 2006 and spring 2007 were used for the study. Using a pre-test/post-test strategy and the

STATPAK (2007) computer program, a t-test was administered to determine significance.

<u>Procedure</u>

The author informed appropriate school board members about the study of *IN*. Once the author informed and received the approval, the author randomly pulled twenty-five fifth grade student files from the chosen school, specifically looking at their WASL scores from the previous two years. Scores were gathered and organized in a table and entered into the t-test portion of the STATPAK computer program to perform necessary calculations. The t-score, degrees of freedom, standard deviation, mean, and probability were then used to determine significance of the *IN* curriculum's effect on student's mathematics WASL scores.

<u>Treatment of the Data</u>

Each student's WASL assessment scores were placed into the t-test portion of the STATPAK (2007) computer program which calculated the sample's t-score. The t-score was then checked against the Distribution Table in the book *Educational Research: Competencies for Analysis and Application* to determine if there was significance in WASL assessment score growth (Gay et al., 2003).

<u>Summary</u>

To answer the question of whether the use of the IN mathematics curriculum improved student mathematics scores as measured by the WASL; a quantitative study was put into action. The twenty-five randomly chosen students from the author's school were given direct instruction in *IN* mathematics in the classroom and were given the WASL assessment in the spring of 2006 and again in the spring of 2007. The data was then used to answer the study's hypothesis.

CHAPTER 4

Analysis of the Data

Introduction

Quantitative data was collected for the study to show if *IN* mathematics curriculum showed significant growth as measured by the WASL over time. After the author randomly picked twenty-five students from the chosen elementary school, the data was organized and analyzed using the STATPAK (2007) computer program. Last, the author used the information to determine if the hypothesis was accepted or rejected.

Description of the Environment

The author chose an elementary school in Eastern Washington that had over six hundred students. The elementary school was located in a growing school district that had a total of eleven elementary schools and was in the process of building more just to keep up with the growing community. The chosen elementary school was the home of one hundred fifth grade students.

The WASL Assessment was given to all fifth grade students in the spring of 2006 and again in the spring of 2007 in their own homeroom. The students had limited time to complete the mathematics portion of the WASL within the classroom environment. The students who were not finished were moved to a different location and were allowed unlimited time to finish their assessment. The mathematics portion of the WASL was given in two days. The students were not allowed to use tools on the mathematics section of the WASL. Pencil and scratch paper were always allowed. No breaks were given until the test was finished.

Hypothesis

The hypothesis for the study was that students who received *Investigations* Mathematics instruction would show significant growth as measured by the Washington Assessment of Student Learning.

Null Hypothesis

The null hypothesis for the study was that students who received *Investigations* Mathematics instruction would not show significant growth as measured by the Washington Assessment of Student Learning.

Results of the Study

After the data was organized and collected the author was able to determine if the new implemented *Investigations* mathematics program that was adopted in the chosen school had any effect on the student's WASL mathematics scores. Twenty-five fifth grade students were randomly chosen by the author and their mathematics WASL scores were analyzed. Of the twenty-five students who were randomly chosen, eight students showed some growth on the mathematics portion of the WASL. The remaining seventeen students scored lower on the mathematics portion of the WASL when they took it in the spring of 2007 then when they took it in the spring of 2006.

Table 1: Students' WASL (2007) Scores

Student	Spring 2006	Spring 2007
1	420	402
2	340	357
3	426	395
4	372	357
5	421	435
6	430	467
7	398	409
8	468	488
9	435	430
10	370	368
11	398	395
12	417	392
13	320	314
14	413	435
15	430	421
16	398	395
17	300	308
18	440	430
19	405	400
20	372	352
21	417	413
22	365	363
23	392	389
24	417	377
25	440	421

The author gathered and organized the randomly selected student scores in Table 1.

Table 2: T-Score Value

Test	N	Mean	Standard Deviation
Spring 2006	25	400.16	39.37
Spring 2007	25	396.52	42.01
df = 24	t = -1.04		p > 0.20

The author placed the students' WASL test scores into the STATPAK (2007) computer program to determine the degrees of freedom, standard deviation, mean and the t-score. The STATPAK (2007) calculated the t-score to be a -1.04. After calculating the t-score, the author used the Table A.4: Distribution of t and determined -1.04<1.318 at the 0.20 level (Gay et al., 2003). Being at the 0.20 level indicated the students did not make significance growth on the mathematics portion of the WASL as shown in Table 2.

Findings

After the author collected, organized and analyzed the data the author found the students made insignificant growth on the mathematics portion of the WASL. The author found the t-score to be -1.04 which showed the probability was greater than the two-tenths level which proved the students' growth was insignificant. Based on the calculated probability, students' scores did not show significant growth, which helped the author determine *IN* mathematics was not helpful in raising students' mathematics WASL scores. Therefore, the hypothesis was rejected and the null hypothesis was accepted.

Discussion

The author strongly believed the *IN* mathematics curriculum was behind the significant decrease in mathematics WASL scores at the chosen elementary school. The author found a relationship between the decrease in mathematics WASL scores and the lack of alignment with the *IN* curriculum and state standards by using the OSPI report on WASL alignment and the state standards. This relationship helped prove the *IN* curriculum was not helping raise student's mathematics WASL scores.

Summary

Fifth grade students were given direct instruction in *IN* mathematics curriculum in the chosen elementary school. All fifth grade students took the WASL in the spring 2006 and in the spring 2007. The author used the twenty-five randomly chosen fifth grade students' mathematics WASL scores to calculate a t-score. The t-score was then used to determine the significance of growth of each student on the mathematics WASL scores. Based on the findings of this study it was determined that the *IN* curriculum was ineffective in raising mathematics WASL scores.

CHAPTER 5

Summary, Conclusions and Recommendations

Introduction

Schools all over Washington State have been adopting new mathematics curriculum in an attempt to raise scores on the WASL. Unfortunately, the implementation of new curriculum was causing student scores to drop creating an opposite effect than desired by public schools. *Investigations* mathematics was just one example of an adopted curriculum that one elementary school had implemented into its daily routine.

Summary

The purpose of the study was to determine if the implementation of *Investigations* mathematics curriculum in the classroom contributed to the drop in mathematics WASL scores. The author randomly selected twenty-five fifth grade students to help prove the null hypothesis.

All fifth grade students received direct instruction in *IN* mathematics at the chosen elementary school for the past two years. The fifth graders took the WASL in their homeroom in the spring of 2006 and again in their homeroom in the spring of 2007.

Conclusions

The author analyzed the data using the t-test. The results of the t-test were calculated to show the significance in WASL scores. The students' mathematical WASL scores taken in the spring of 2006 were reported to be higher than those WASL scores taken in the spring of 2007. Students' scores on the math portion of the WASL decreased.

Recommendations

Based on the conclusions from the study, the author recommends educators using the *IN* curriculum supplement mathematical material in the classroom to meet all the requirements on the state assessment. The author does not believe *IN* is a bad program but that *IN* is not a program that meets the majority needs of the math portion of the WASL.

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Table 3: Program Alignment

Investigations Mathematics Curriculum				
Grade	Strongly Aligned	Adequately Aligned	Partially Aligned	Not Aligned
K	70%	16%	12%	2%
1	70%	18%	9%	3%
2	46%	22%	25%	6%
3	43%	15%	19%	23%
4	40%	13%	23%	24%
5	38%	12%	21%	29%