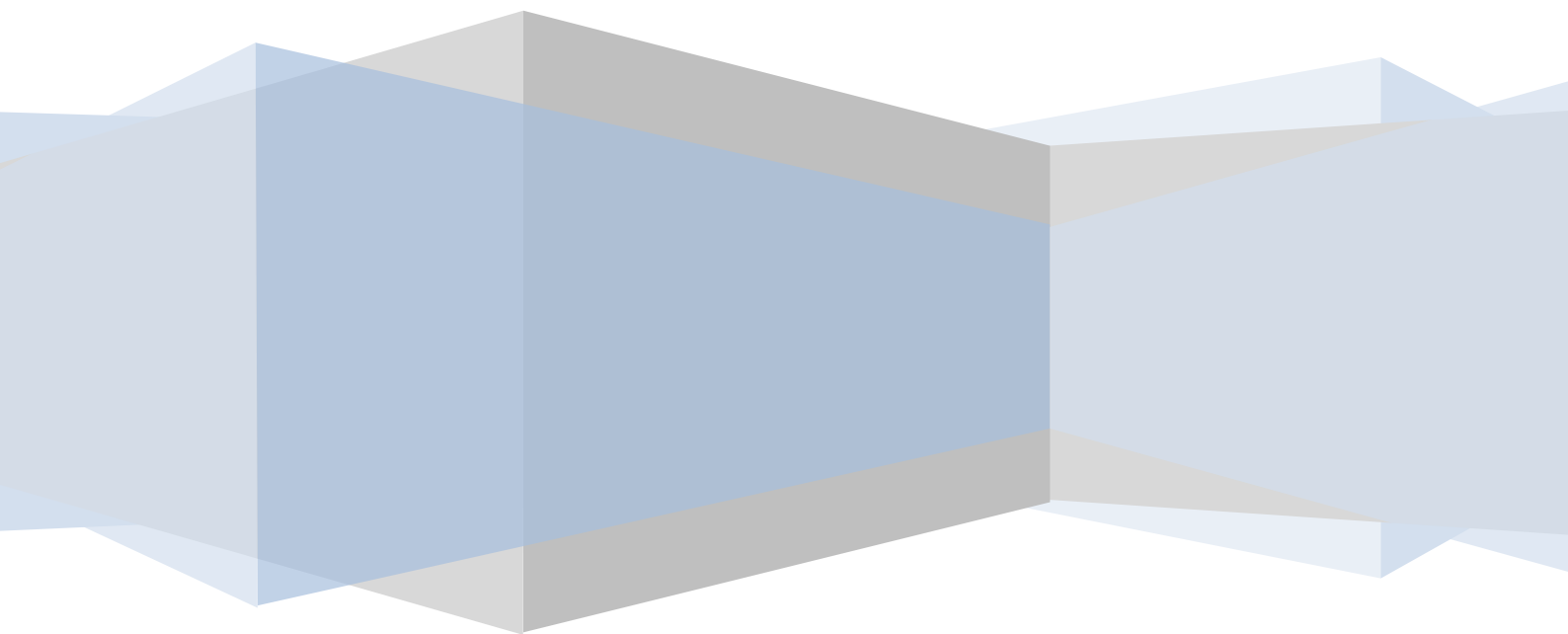


University of Wisconsin-Parkside

**No More Fingers:
Achieving Automaticity of Basic Facts through Systematic Practice**

**Shi Hae Kim
University of Wisconsin-Parkside**



ABSTRACT

The purpose of this study was to examine the effect of a systematic computation program on math competency. The findings to the research questions showed that practicing the E.nopi MATH program actually improved math competency for first and second grade students. The first grade students made larger gains after only a year of practice with the program. The difference in increased scores between the lower and higher group of first grade students was not statistically significant; however, the second graders' difference was statistically relevant between the lower and higher groups. Factors for achieving math automaticity were found to be prompt feedback, consistent practice, an individualized program, and incremental progress. By practicing the program, students were exposed to a diverse range of questions, developed new math strategies, reduced their usage of finger counting, and developed independence as well as a habit of checking answers.

INTRODUCTION

Finger counting is a commonly seen phenomenon in primary grade math classes. The National Research Council presents diverse views on counting and its relationship with procedure skills; one of the views is that conceptual and procedural knowledge of counting develops interactively, interdependent on each other (Kilpatrick, Swafford & Findell, 2001, p.161). Using fingers to perform basic addition and subtraction is a concrete representational activity for young children. However, if counting by fingers is continually used to solve advanced computational problems, it can create difficulties. Students are expected to master basic facts and once this is accomplished, they should not need to resort to finger counting. Mastery of basic computational skills provides the tools to perform advanced mathematics (NCTM, 2001). Mathematical proficiency develops over time, so if the students persist in counting on their fingers for computations, it is a sign that their procedural skills have remained fixed at the basic level. Research has provided evidence of the correlation between computational fluency and mathematical competencies (Kilpatrick, Swafford & Findell, 2001, p. 122; Kim & Davidenko, 2007). Concerns have been raised that students relying on counting with fingers to solve basic computation problems are unlikely to develop efficient and accurate fluency in mathematics. Additionally, these students often face difficulties as they attempt to solve more advanced mathematical problems.

Need for This Study:

NCTM's most recent recommendation is developing quick recall of addition and subtraction facts by the second grade (2006, p.14). The automaticity level, so named by NCTM, of recalling of addition and subtraction facts can be achieved through practice. Kilpatrick, Swafford and Findell (2001, p.121) state that for

computational procedures to be efficient and accurate, students have to practice to maintain fluency. Students should have enough time to practice addition and subtraction facts to recall them at the automaticity level.

This study will provide important data to elementary math educators for the support of children in the practice of addition and subtraction basic facts using a computation practice program called E.nopi MATH.

Value of the Study:

This present study is prompted by increased concern regarding the requirement of NCTM for primary grade students to achieve the automaticity mastery level of computational fluency. Most recently in its *Curriculum Focal Points for Pre-K through Grade 8 Mathematics*, NCTM emphasized the need for attaining the automaticity level of computational skills by the second grade (NCTM, 2006, p. 14). They agreed that computational fluency is a tool for solving higher level math problems. Children use their understanding of addition to develop quick recall of basic addition facts and related subtraction facts (NCTM, 2006, p. 14). The National Research Council (Kilpatrick, Swafford & Findell, 2001) also concurred with the NCTM position that procedural fluency is the basis for developing strong conceptual understanding of mathematical ideas.

The purpose of this study is to assess the implementation of the E.nopi MATH program with the 2007-08 cohort of first and second graders for one school year. The measured effectiveness of the program for improving computational fluency among this cohort addresses several research questions:

1. Will there be any difference between the E.nopi MATH and control group in gained scores?

2. Will there be any difference in progress between the grade levels within the E.nopi group; between the higher and lower group?
3. Will the pretest score be correlated with the post-test scores?
4. Did the number of booklets completed affect the post-test scores?

Purpose of This Study:

The purpose of this study is to prove, through use of a systematic math program, that practicing addition and subtraction facts will improve mathematical fluency of first and second graders. This study will attempt to test if a desired automaticity level of basic facts is achieved, and students will show improved scores on the Measures of Academic Progress (MAP) math test. Practicing with a systematically designed math computational program during a school year for 10 minutes a day should, for most students, bring them to a higher level of automaticity. Students' MAP test scores from the end of the previous school year (prior to the intervention) were compared to their scores at the end of the current school year (after the intervention) for both E.nopi and control groups. In addition to evaluate the effectiveness of the math program, this study will also investigate the factors that contribute to improving math automaticity and the side effects of the math program on students' learning.

LITERATURE REVIEW

This literature review is divided into six sections: The current status of math performance among U.S. students, computational skills, multiple representations: using up to the symbolic level of representations, cognitive learning theory and the methods to achieve automaticity and E.nopi MATH.

The Current Status of Math Performance among U.S. Students:

Mathematics has been an important subject in after school programs, second only to reading. Improving students' mathematical fluency in the primary grades must become a major concern for American educators as it is critical to the overall math achievement for American students.

International, national and state assessments have revealed a consistently low pattern of achievement in American students' mathematics progress. The international ranking of U.S. students continues to decline. Reports from international assessments of students' mathematics competency have shown that the performance of American students is low compared to that of students from other developed countries. Results of the Trends in International Mathematics and Science Study (TIMSS) in 2007 reported that 8th graders from Chinese Taipei, Korea, Singapore and Hong Kong received the top four rankings while the students from the U.S. were ranked as 7th out of 16 countries classified by the International Monetary Fund (IMF) as advanced economies (The Educational Trust, 2008).

Another major international study on mathematical achievement, the Programme for International Student Assessment (PISA) (Baldi, et al. p.11, 2007) reported a similar result. In PISA 2006, the U.S. performance in mathematics literacy was lower than the average performance among most of the developed

OECD countries and below the average of the group. Out of those 57 participating countries U.S. ranked number 32 (Baldi, et al. p.11, 2007).

National assessments have revealed that a great number of American students perform below national standards. In the past 30 years, a series of national assessments have been implemented to track U.S. student achievement in mathematics. The overall level of achievement in mathematics has increased during this period. Between 1990 and 2007, the Nation's Report Card and the National Assessment of Educational Progress (NAEP) reported that the percentage of fourth graders performing at or above Basic level increased from 50% to 82%, and the percentage performing at or above Proficient level increased 13% to 39%. However, it is of great concern that 18% of students are still at or below the Basic level in mathematics achievement nationwide (The Nation's Report Card, 2007a). It should also be noted that while national standards are being met by more U.S. students; the overall standing of U.S. students internationally is still in decline. Future studies might compare the ages/grade levels at which topics are introduced and when computational mastery is expected. Future studies might also look at the demographics of those students at or below basic competency in the primary grades.

At the state level, the 2007 Wisconsin Knowledge and Concept Examination (WKCE) math test results for 4th graders revealed that 38% were at the basic level, 40% were at the proficient level and 7% were at or above the advanced level (The Nation's Report Card, 2007b). While this is a large percentage of success, it also means that 15% of fourth graders in the state of Wisconsin failed the expectations for the target grade-level mathematics fluency. It can be predicted that without intervention, the trend will continue and the

number of students failing to meet the basic level of mastery will increase.

Each level of the evaluation studies demonstrated U.S. students' math performance is below expectations and should cause great concern for educators.

Computation Skills:

National and state math organizations such as the National Council of Teachers of Mathematics (NCTM, 2000, 2004, and 2006), the National Research Council (Kilpatrick, Swafford & Findell, 2001) and the Wisconsin Knowledge and Concept Examination (WKCE) (Webb, 2002) have consistently revealed and identified the need for mastery learning of basic facts for computation.

The national learning standards for mathematics suggest that computational fluency is a major component of the mathematics curriculum in grades three to five (NCTM, 2000, 2006; Kilpatrick, Swafford & Findell, 2001). The NCTM's *Principles and Standards for School Mathematics* (NCTM, 2000) claims:

A major aim in grades 3-5 is the development of computational fluency with whole numbers. Fluency refers to having efficient, accurate, and generalizable methods (algorithms) for computing that are based on well-understood properties and number relationships. Some of these methods are performed mentally, and others are carried out using paper and pencil to facilitate recording of the thought process. Students should come to view algorithms as tools for solving problems rather than as the goal of mathematics study (p. 143).

NCTM also highlighted the importance of speed and accuracy in demonstrating mastery of the basic facts in computation. To achieve this goal, NCTM (1989) suggests that “practice designed to improve speed and accuracy should be used, but only under the right conditions: that is, practice with a cluster

of facts should be used only after children have developed an efficient way to derive the answers to those facts” (p.47).

The relationship between computational proficiency and mathematical proficiency is well theorized in the National Research Council report (Kilpatrick, Swafford & Findell, 2001). The Council described mathematical proficiency as being composed of five intertwined and interdependent strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Computational skills such as knowledge of procedures, knowledge of when and how to use them appropriately and skill in performing them flexibly and efficiently are especially needed to support conceptual understanding. The Council stated specifically that students need to be efficient and accurate in performing basic computations with whole numbers without needing to refer to a table or other visual aids (2001). The council also recommended that students reach an automatization level of proficiency in computational skills in order to achieve a higher level of overall mathematical fluency (Kilpatrick, Swafford & Findell, 2001).

Multiple representations: Using up to the symbolic level of representations:

Bruner and Piaget (as cited in Burris, 2005) argued that knowledge could be represented in three ways: concrete, pictorial, and symbolic. To attain conceptual understanding, students should be exposed to the three forms of representation until they are able to fluently move back and forth between them. The use of multiple representations is strongly supported by the NCTM, particularly for the primary grade students, to make mathematical ideas more concrete and available for later reflection (NCTM, 1989, 2000).

Using multiple representations and strategies to support students in

gaining confidence in math has been the NCTM's general position on teaching computational skills. The NCTM (1989) has advocated starting to teach whole number computation by emphasizing underlying concepts; using concrete representation to model procedures and develop thinking patterns. It also stresses the use of symbolic level exercises to master computational skills including the use of paper-and-pencil computation and estimation (p.47). By doing this, students can gain confidence in their math abilities.

Another reason students need to practice symbolic level representation is because mathematics is abstractive knowledge. Ross (2001) argued that the construction of math concepts is an abstract-cognitive process. To learn number operations meaningfully, students should be able to move from the concrete level to the pictorial and symbolic levels as they are developing computational algorithms. The teachers should evaluate students' work, help students recognize efficient algorithms and provide sufficient and appropriate practice so students become fluent and flexible in computing.

There is a difference in the way American primary teachers and students use multiple representations in schools compared to Asian school practices. Geary, Bow-Thomas, Liu and Siegler (1996) compared how Chinese and American elementary students from grades K-3 employed solving strategies. They found that Chinese students used more verbal counting and decomposition while their American counterparts used more finger counting to solve addition problems. Cai (2006) interprets these phenomena as the result of teachers' use of specific types of representation influencing students' use of more or less generalized strategies. If American teachers spend most of the instructional time using concrete and pictorial representational instruction, it is likely that students will not be able to

generalize their learning in the higher symbolic level of representation; without using effective strategies, students cannot accomplish mastery of the concepts or skills (Cai, 2006).

Successful teaching and learning require good content knowledge and appropriate use of pedagogy. Effective teaching requires not only content knowledge but also an adequate representation of mathematical ideas and relationships to foster students' learning (Cai, 2005). In his studies, Cai compared U.S. and Chinese teachers' use of representations in teaching mathematics. Both American and Chinese teachers value the symbolic level of representations in evaluating students' work; however, the U.S. teachers held a much higher value for the response involving concrete strategies and visual representations than did Chinese teachers. The concrete or pictorial responses were less generalizable even though the answers were correct. Cai (2005) explains this as the reason why U.S. students tend to choose concrete or pictorial representations when they answer math problems while Chinese students tend to use abstractive symbolic level representations in answering math questions. Cai (2005) concluded that concrete and pictorial levels of representation could be used to introduce concepts at the entry level of understanding since U.S. students have generalizing problems which may limit their thinking and inhibit higher levels of learning. Accordingly, teachers need to start with concrete representations using physical manipulatives to support students in developing their own strategies for solving problems and making sense of mathematics. In order to help students understand mathematical concepts at higher levels and develop more generalized solutions, concrete and pictorial level of representations are not enough. Students need to have more experience with the symbolic level of representations to arrive at generalized

solution representations and strategies. (Cai, 2005)

Cognitive Learning Theory: The Importance of Automaticity in Computation

Skills and the Methods to Achieve Automaticity:

The major concept that is studied here is ‘automaticity.’ The word automaticity is commonly used in disciplines such as language learning and music as well as mathematics. Automaticity is characterized by speed, accuracy and fluidity of action (Segalowitz, 2003, p. 200). In math, it can be demonstrated by the ability to complete computational problems within two seconds of visual and auditory presentation of the problem (Bender, 1998). Using fingers is a clear sign that the student needs concrete representational aids to compute and also shows that they have not mastered the concept to the point of automaticity.

Repetition and drilling are not seen as productive practice in education. In math education, to learn and master basic facts using this form of learning is debatable. However, in the areas of playing musical instruments and sports, repetition and drill are considered valuable practices. Kohn (1998) advocates the value of drill and practice as a tool in basic academic skills to help students become more fluent readers and skilled calculators.

Automaticity may be an outcome of mastery learning and helps slow-learning students to gain mastery of basic skills. Repetition and drilling can help students to achieve automaticity of basic skills. Haught et al. (2002) proposed well-ordered or organized math programs such as Kumon (Reingold, 1990) and Strategic Math Series (Miller & Mercer, 1997). Repeating and drilling with systematically ordered program helps students master basic skills. Kulik et al. (1990) meta-analyzed 108 mastery learning programs for attitudes toward

instruction, attitudes toward content, and course completion as well as performance at the end of instruction and found mastery learning helped to improve learning for students.

Cognitive scientists believe that when computation skills are mastered through practice, activities become automatized and take up very little space in working memory. Thus, students can devote available working memory capacity to other more complex or higher level tasks and problems (McDevitt & Ormrod, 2004). Without mastering basic computational skills, students' mathematical problem solving performance can be slowed down because they use their cognitive ability to review computational procedures.

The importance of mastering basic facts for young children has been studied in a research cited by Henry and Brown (2008) which confirmed the theory of basic-facts learning; that children strengthen the association between basic-fact problems and their answers through repeated practice, building stronger bonds that lead to confident retrieval from long-term memory. Students are required to be efficient and accurate in performing basic computations with whole numbers; they can improve over time with practice to help maintain fluency (Kilpatrick, Swafford & Findell, 2001, p.121).

Many primary grade students demonstrate problems in math as well as reading. Children with learning disabilities in the area of math usually experience problems in counting, writing numerals, and learning basic concepts. (Fleischner, Garnett & Preddy, 1982; Christensen & Gerber, 1990). These studies also have shown that repetition and drilling helped learning-disabled students learn basic facts. (Fleischner, Garnett & Preddy, 1982; Christensen & Gerber, 1990).

To achieve automaticity, Davis (1978, as cited by Robinson, 1999) offered ten suggestions for math automaticity practices:

1. Children should attempt to memorize material they reasonably understand.
2. Have children begin to memorize basic arithmetic facts soon after they demonstrate an understanding of symbolic statements.
3. Children should participate in drills with the intent to memorize.
4. During drill sessions, emphasize memorization- don't explain.
5. Keep drill sessions short, drill every day.
6. Try to memorize only a few facts in a given lesson, constantly review previously memorized facts.
7. Express confidence in your students' ability to memorize- encourage them to try memorizing and see how fast they can be.
8. Emphasize verbal drill activities and provide feedback immediately.
9. Vary drill activities and be enthusiastic.
10. Praise students for-good-effort-keep a record of their progress

E.nopi MATH:

The E.nopi MATH program is one of a few specially *designed* programs whose intent is to provide conditions to develop and increase computational competency. E.nopi MATH was developed in 1975 in Korea as a program to teach mathematics to students from kindergarten to eighth grade. Currently, it is the most widely used supplemental program for after-school mathematics instruction in Korean homes. By the year 2004, more than 2.4 million students were enrolled in the E.nopi program in Korea.

E.nopi MATH is characterized as individualized and student-initiated learning and was designed to fit each individual student's ability level regardless of age or grade. During instructional time in the mathematics classroom, it is difficult to give students individualized support. It is envisioned that a teacher may effectively instruct students with diverse mathematics ability levels teaching in large or small groups, while E.nopi would support students individually at their own levels.

The E.nopi MATH curriculum uses a series of colorful leveled booklets based on incrementally graduated steps, prompt responses, and self-checking. Students' progress is determined by correct completion of the small steps allowing the students to proceed through the booklets to the next level without requiring the teacher's direct instruction. Each finished booklet is graded and returned to the student so the student can check his/her mistakes and make corrections. Students normally can complete half of a book, 8 pages, in a 10 minute period.

E.nopi MATH emphasizes computational skills and pursues the automatization level of carrying out computations. The E.nopi MATH program was brought to the United States and modified for use in a public school setting. Kim and Davidenko's 2007 study completed in 2004-2005, involved two fourth grade classes in New York state. The results showed that students who consistently practiced E.nopi MATH in addition to the regular math curriculum demonstrated improved math skills and performed better on standardized tests than students who did not have access to or participate in the program.

Students who regularly exercise their “Math Muscles” can develop computational fluency using the individualized, systematic approach of E.nopi MATH. The E.nopi MATH program can be likened to exercises tailored to the needs of each student. Students who move through the exercises consistently will build on their knowledge of math over time and become computationally fluent. Computational fluency at the mastery level will enable the students to move more easily into more advanced mathematics.

DESIGN OF THE STUDY

This on-going research is being conducted at Lakeshore¹ Elementary School in Southeastern Wisconsin and is characterized by robust collaboration with the teachers and principal. The purpose of this study is to discover the effects of systematically practicing computation skills to improve mathematic competency beginning in the first and second grades. A commercially designed computation practice program is used every school day throughout the school year to help the students develop speed and accuracy as they move toward the automaticity level of computation. To distinguish the effectiveness of the program, the experimental (E.nopi-using) and control group's Measures of Academic Progress (MAP) scores have been compared. Interviews with students and teachers were conducted, and analysis of the interview material will disclose the thoughts and understanding of the students' and teachers' experience with the program and the students' understanding of math.

Participants

The control group was made of first and second graders in the 2005-06 school year. The control group did not practice with E.nopi MATH. They only practiced with Saxon Math which the school had adopted for general use.

The experimental group was also taught math using Saxon Math. However, in addition to their regular daily math sessions, the students in this group were given a daily 10 minute E.nopi MATH period. Each student was given a diagnostic test and placed in booklets appropriate to their specific level.

The students worked at their own paces. The participants in this study included

¹ The name of the school is an alias .

the entire group of students in first and second grade classes. A total of 109 students, 55 first and 54 second graders, initially participated; after a year of implementation, three students moved to a new school, leaving 106 students in the study. Three first grade and three second grade classes were asked to participate. Ten students were classified as needing an Individual Education Plan and received E.nopi MATH practice throughout the school year; however, their scores were not included for data analysis.

Based on convenience, the control group included the entire group of first and second graders from the same school for the 2006-07 school year. Six of those students were identified as having an IEP and those six students practiced with the E.nopi MATH program for the school year but were not included in statistical analysis.

Participating School

Lakeshore Elementary School serves K-8th grade in a refurbished industrial space near the downtown area. Lakeshore Elementary School serves K-8th graders and 68.4% of the students received free or reduced lunch while the district average was 49.2% and the Wisconsin State average was 32% in the year of 2008 (Wisconsin Department of Public Instruction, 2008). At Lakeshore School, academic performance is below the district and state level: 68 percent of the fourth grade students were at or beyond Basic level, and 32 percent were below grade level on Wisconsin Knowledge and Concepts Exam math test. This school district has an average percentage of 77 for students at or beyond grade level, and 23 percent were below grade level in the year of 2007 (Wisconsin Department of Public Instruction, 2007). At the state level, 87 percent of fourth graders are at or beyond the grade level, and 13 percent demonstrated below

grade level performance in math. This school displays a concentration of students achieving below state norms.

Data Collection Instruments and Procedures

To measure the productivity of the daily supplemental program, each student's completed booklets were recorded. Measures of Academic Progress (MAP) test scores from fall of 2007 and spring of 2008 were used to determine students' progress. Additionally, interviews with teachers and students were conducted to find out about their experiences with E.nopi MATH as well as their perspectives on math teaching learning. MAP achievement tests are electronically administered and scored and are designed to measure growth for individual students, classrooms, schools, and the district. The tests measure students' general knowledge in reading and math.

Program Implementation

Each of the three first and second grade teachers received training for administering the E.nopi MATH program. In early October 2007, all participating students were tested to measure their computational levels. Using the data from the test, each student was assigned a starting level in the booklets. Students are expected to finish about 8 pages, (half of a booklet), a day. Teachers were to implement the program consistently every school day after lunch hour for 10 minutes. Graders were provided by the university. The teacher's job was to give out the correct booklets, set the time, collect the booklets after 10 minutes, and to answer students' questions.

Design of the Study

Both the experimental and control group were taught math using the school's Saxon Math curriculum. In addition to the regular daily math lessons, the experimental group practiced E.nopi MATH for an additional 10 minutes, while the control group only used Saxon Math. Students worked in the booklets each day making corrections on pages where graders found errors and starting new booklets. Student could not move on to the next level until all corrections had been made in the booklets from the previous level. Since each student was tested and given booklets at their correct level of ability, most students could move as expected, half a page a day. The program was in place from the beginning of October until the end of the school year, June 10th. MAP pre-test was given on September 25th and the posttest conducted on May 15th 2008.

Analysis of the Data

Analysis of the MAP scores for both the control and the experimental group will be compared. First, the comparability of the pretest results will be tested and results of the post test was examined.

All of the students in the study will be given a code number to identify and protect their identity. Analysis of the data provided for the study required two separate statistical procedures; an independent samples t-test to compare pretest scores of the control and experimental groups and independent samples t-test to determine if posttest scores of the experimental group were statistically significantly greater than those of the control group.

A bivariate regression test will be used to determine factors which attribute the post test scores.

RESULTS

The purpose of this study is to prove that mastering basic addition and subtraction by practicing the E.nopi MATH program will improve mathematical fluency in general. Measures of Academic Progress (MAP) math test was used to check mathematical fluency. It was hoped that practicing E.nopi MATH for a school year would bring students to higher level of mastery of addition and subtraction skills. The scores of the end of the prior intervention school year and the end of the after the intervention school year were compared for each child who participated in the experimental group. Their scores were compared against those of the control group students.

It is essential to check the equivalence of the control and the experimental group before the intervention. Some extreme scores and IEF students' scores were removed to create equivalent experimental and control groups. Table 1 and 2 contain information about the groups' equivalency on the pre-MAP test. Data analyses demonstrated that at the time the pre MAP test was taken, the experimental and control groups of students were equivalent on this measure. For both first graders and second graders, the control group is comparable to the E.nopi group. The mean scores on the pre-test were very close, and the tiny differences found are not statistically significant.

Table 1. *First Graders -- Experimental and Control Group's Test Scores at the Beginning of the School year: A Test of Comparability Using t-test.*

Group	n	mean score	t	p
Experimental	43	160.91	-0.351	0.726
Control	43	161.65		

*p<.05. **p<.01. ***p<.0001

Table 2. *Second Graders -- Experimental and Control Group's Test Scores at the Beginning of the School year: A Test of Comparability Using t-test.*

Group	n	mean score	t	p
Experimental	47	180.94	.093	0.926
Control	44	180.73		

*p<.05. **p<.01. ***p<.001

The effects of E.nopi MATH on math competency on MAP tests demonstrate that for both first and the second graders the E.nopi group made greater gains than the control group. Table 3 shows the gained scores of each group and Tables 4 and 5 show the statistical results of the gained scores.

For first graders, the control group made an 8% gain and the E.nopi group made an 11% gain. This 42% difference is statistically significant at the .001 level. For second graders, the E.nopi group made a 7% gain and the control group made a 5% gain. This is a 45% difference, and it is also statistically significant at the .001 level. There is no difference in progress in math fluency between the grade level. Both grades made statistically significant progresses.

Table 3. *Gained Scores for First and Second Graders*

Grade	Group	n	Pre Mean Score	Post Mean Score	Gains
1st	Experimental	43	160.91	172.21	11.30
	Control	43	161.65	169.63	7.98
2nd	Experimental	47	180.94	188.24	7.30
	Control	44	180.73	186.23	5.05

Table 4. *First Graders -- Experimental and Control Group's Percentage Gains: A Test of Comparability Using t-test.*

Group	n	Percentage gain	t	p
Experimental	43	11.30	3.52	0.001***
Control	43	7.98		

*p<.05. **p<.01. ***p<.001

Table 5. *Second Graders -- Experimental and Control Group's Percentage Gains: A Test of Comparability Using t-test.*

Group	n	Percentage gain	t	p
Experimental	47	7.30	3.47	0.001***
Control	44	5.05		

*p<.05. **p<.01. ***p<.001

There is correlation between pretest scores and gained scores. Bivariate regression shows a significant impact of pre-test score on percentage gained. Those with lower pre-test scores gained more. For first graders, the r-square value is .241. For second graders, the r-square is .314.

Tables 6 and 7 show the correlation between pretest scores and post-test for each grade. In the case of first graders, there was no significant difference in the percentage gained by those with low pretest scores and those with higher score. In the case of the second graders, those in the E.nopi group with pretest scores lower than the median gained, on average, 41% more than those in the E.nopi group with higher pretest scores, and this is statistically significant at the .005 level.

Table 6. *First Graders – Percentage Gains of Those with Low Pretest Scores Versus Those with High Pretest Scores: A Test of Comparability Using t-test.*

Pretest Scores	n	Percentage gain	t	p
Low	21	12.29	1.50	0.141
High	22	10.36		

*p<.05. **p<.01. ***p<.001

Table 7. Second Graders – Percentage Gains of Those with Low Pretest Scores Versus Those with High Pretest Scores: A Test of Comparability Using t-test.

Pretest Scores	n	Percentage gain	t	p
Low	23	8.57	2.99	0.005**
High	24	6.08		

*p<.05. **p<.01. ***p<.001

For both grades, the number of books completed did not statistically affect the gain within the E.nopi group. The range of completed booklet numbers for the first graders is 18-83 with the average of 51 while the second graders is 31-107 with the average of 66. The correlation of number of books completed and percentage gain in test scores (r-square) was .005 for first graders and .019 for the second graders.

DISCUSSIONS

In an effort to increase student math scores and improve math competency, the ten minute per day, timed computation practice using the E.nopi MATH was implemented for the school year of 2007-8. This discussion will center on four areas: differences in gained scores, differences between grade levels, correlation between pre-test and post-test scores and booklet completion.

Based on the results of statistical analysis, the findings indicate that E.nopi MATH helped students in gaining competency in mathematics. The E.nopi group gained more than the control group. The gained scores of the first graders were greater than those of the second graders. This may be interpreted as first graders' scores being lower than the second graders, and the progress was regressed since the gaps between the first graders were wider.

The effects of E.nopi MATH on math competency as determined by the Measurements of Achievement Progress (MAP) tests demonstrated that for both first and second graders, the E.nopi group made greater gains than the control group. This finding is aligned with the statement of the National Research Council's claim that computational proficiency and mathematical proficiency are interdependent. (Kilpatrick, Swafford & Findell, 2001) The Council conceptualizes the five components of mathematical proficiency, (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive dispositions), as being interdependent and intertwined. Computational skills are especially needed to support conceptual understanding. The Council also recommends that students reach an automatization level of proficiency in computational skills in order to achieve a higher level of overall mathematical fluency (Kilpatrick, Swafford & Findell, 2001). Practicing E.nopi MATH helped

students to achieve a higher level of automaticity in addition and subtraction; the advanced level of automaticity made it possible for students to attain higher scores on the math competency test.

Another explanation for achieving higher gained scores with the E.nopi group is that the E.nopi first graders had greater exposure to solving math problems which, in turn, prepared them for taking the MAP test. We can see the result of the practice effect. Practice effects (Kaufman, 2003) are defined as “gains in scores on cognitive tests that occur when a person is retested on the same instrument, or tested more than once on very similar ones.” Even though the E.nopi group students were not tested by the exact same instrument, the E.nopi group did, indeed, have more test-like experiences than the control group. This phenomenon is more apparent for the first graders since they typically do not have test taking experiences or activities on a daily basis.

The first graders evidenced difficulty with reading at the beginning of the school year and later on with different types of E.nopi MATH questions, both of which caused classroom teachers and E.nopi graders to read and explain questions to students during the Enopi. MATH time. After a month, when the students began to read and understand the questions, they began to make fewer mistakes and ask for less help.

For the first graders, there was no significant difference in the percentage gained by those with low pretest scores and those with higher scores. This suggests that both low and high achievers received equal benefit from the program. It seems there was a practice effect evidenced for the first graders. First graders are not generally accustomed to timed tests; the E.nopi students were exposed to a timed test every day, so they may have become more used to test

taking than the control group.

The second graders revealed a different finding. In the case of the second graders, those in the E.nopi group with pretest scores that were lower than the median gained, on average, 41% more than those in the E.nopi group with higher pretest scores; this is statistically significant at the .005 level. Based on the statistical analysis, the lower group of the second graders received the most benefit from the program.

For both grades, the number of books completed did not statistically affect the gained scores within the E.nopi group. The range in number of completed booklets for the first graders is 18 to 83 with the average of 51 while the second graders ranged from 31 to 107 with the average of 66. The second graders completed more booklets than the first graders. When the project was planned, it was expected that the students would complete about 60 booklets in a school year based on 188 school days. The program started 7 weeks after the first day of the school. Factoring for holidays and other special occasions and given the late starting date, we expected students could realistically do E.nopi MATH on 140 days. Each student was expected to finish a half a booklet, eight pages, each day. Students had to make corrections on any problems missed in a booklet, so there were periodic delays for students in their progress through the eighteen books in each level. The number of completed booklets was beyond our expectation for the second graders, but it was slightly below our expectation for the first graders.

When we take out the extreme numbers, the average number of booklets completed by students was about 60. It is assumed that since the students completed enough booklets to approach automaticity in addition and subtraction computational skills, after completing a sufficient number of booklets, the number

of booklets did not affect the outcome of the math fluency test scores. In the opinion of the researcher, it is the consistent use of the program that is the critical component of the intervention. Since the E.nopi MATH program is designed to progress in small graduated steps, the students should have frequent and regular opportunities to complete enough booklets to implant and sustain their growing automaticity. The E.nopi students' completion of booklets demonstrably contributed to their growth in math skills.

AUTOMATICITY PRACTICE FACTORS AND IMPLICATIONS

Five factors contributed to achieve automaticity

Five components helped students to improve their basic math fact automaticity levels: prompt feedback, everyday consistent practice, an individualized program to fit each student's math level, progress in small steps, practicing symbolic paper and pencil representation.

First, immediate feedback is an essential factor in improving automaticity (Davis, 1978, as cited in Robinson, 1999). Promptly returning the graded booklets to the students in order to provide feedback is a major principal of the program. However, the collecting, grading and returning of the booklets was not always done properly. Many times either grading or distribution of booklets was delayed; when this occurred, students progressed into new booklets without receiving prompt feedback, nor the timely opportunity to make corrections. Ideally there should never have been more than a four book span in the booklets a student was working on; however, due to logistical difficulties some students attained a span of 10 or 12 books which hampered their development of automaticity. Receiving feedback quickly on their work allowed students to see their mistakes and correct

them. When prompt feedback was given, the number of errors was reduced.

Second, practice in the booklets should be short but consistent to achieve the automaticity level in computational skills which form the foundation for higher level math. (Davis, 1978, as cited Robinson, 1999) By creating the 10 minutes period each day after lunch to be implemented systematically and consistently, E.nopi MATH helped most first and second graders to achieve the automaticity level of computational skills. Consistent practice is aligned with the thinking of Kohn(1998). He advocates the value of drill and practice as a tool in basic academic skills in order to become more fluent readers and skilled calculators. Most E.nopi MATH students improved their addition and subtraction computational skills and were reasonably able to memorize the facts and understand the E.nopi questions. Once they were used to the program, most students could do it easily and complete the evaluation questions at the end of each booklet without making mistakes. E.nopi MATH helped them to practice basic facts using meaningful practice with the intent to achieve automaticity.

Third, to promote mastery of the concepts and skills, it is critical to have the program be individualized. E.nopi MATH was designed to create progress based on one's own ability. Each child is tested at start of the year, an appropriate beginning level is determined, and s/he progresses based on her or his own ability. E.nopi is customized to fit each student, and they can see their own progress. When children see their own progress in the booklets, they feel confident with what they are doing and enjoy doing it more. They do not feel frustration because the booklets fit the individual levels. This lack of frustration is most likely the reason the first and second grade students enjoyed the E.nopi program. Once E.nopi MATH became routine and students were accustomed to it, they began to

express this interest to their teachers. When they missed their E.nopi MATH time, (holidays, half-days and special assemblies), students asked for it. They were internally motivated to work on their math. As students began to notice they were not making as many “silly mistakes” and completed more booklets, they became more confident. Internal motivation can be achieved through competition within oneself. The students were actively engaged in monitoring their own progress as they completed booklets and moved ahead.

Fourth, programs aiming for mastery of skills should progress in small steps, and students should practice with them daily. (Davis, 1978, as cited Robinson, 1999) Since the E.nopi MATH program was designed to progress in small steps and constantly review what students had mastered, most students could memorize basic facts without difficulty. Students liked working in the booklets and did not need external reinforcement nor the teacher’s instructions to do it every day.

Fifth, practicing symbolic level representation with paper and pencil causes students to achieve higher levels of addition and subtraction computation skills. Cai (2005, 2006) advocated the value of the symbolic level representation practice to master math concepts. The E.nopi MATH program, which is based on paper and pencil symbolic level practice, enabled students to achieve higher levels of automaticity in computational skills.

Additional Outcomes

As a result of practicing E.nopi MATH for an entire school year, the following outcomes were observed: exposure to diverse math questions, development of math strategies, less finger counting, more independence in doing math, checking of answers and improved concentration levels.

It is important to expose students to various types of questions to make sure

they understand math concepts clearly. Initially, the students were not familiar with some types of E.nopi questions. By doing E.nopi MATH they were exposed to different terminology and question styles. E.nopi booklets challenged students with a diversity of math questions, but eventually this variety in type of question helped students to understand math in more varied and complete ways.

Interviews with students showed that the higher achieving group within each grade uses more varied and effective strategies when doing addition and subtraction (five to seven strategies for eight questions) while the lower achieving group used fewer and inaccurate strategies (zero to two strategies for eight questions). It is not clear how much E.nopi math contributed to strategy usage for the primary grade students. However, it is obvious that using effective and varied strategies was positively related to the performance level.

After practicing with E.nopi MATH, many students relied less on or stopped using finger counting altogether which indicates that they began to internalize number concepts and develop math strategies. It should be emphasized, however, that students should be allowed to use fingers until they establish a number sense and computational skills. Some students made excessive numbers of errors, and the researchers found that many of those students had been directed by their teachers or parents to not use finger counting at all. Fingers are usually used as the first concrete representational tool. Using fingers is not a bad practice for young children; unfortunately, problems arise if the student relies on fingers too long. Once students understand the number concepts and master addition and subtraction basic facts, they do not need to use fingers. If students are forced to not use fingers before they master the facts, these students have no concrete representation to use. Students tended to make excessive numbers of errors when

they had been asked or directed to not use their fingers before they had mastered addition and subtraction computation skills.

Doing math unaided is an additional benefit of practicing E.nopi MATH. At the outset of the program, students asked many questions which created a hectic pace for the teachers in trying to help those students during the short work period. As previously stated, many of the students' questions came from not understanding the questions in the booklets; most students when confronting a new type of exercise did not attempt to solve the problem. These students raised their hands and asked the teacher what to do instead of trying to do it alone. When students do attempt to solve the problems by themselves, they construct mathematical knowledge. As time passed, students began to remember how to do the different exercises and complete them without asking questions. Doing math independently, unaided, became an accustomed habit.

Checking answers should be encouraged for all students. National Research Council valued self-monitoring approach as one of three basic learning principals. (Donovan & Bransford, 2005) The self-monitoring approach can support learners develop the ability to think meta-cognitively and take charge of their own learning, consciously identify learning goals, and assess their development in achieving them. (p. 10) Effects of self-monitoring were studied using mathematics task showed improvement on arithmetic productivity and accuracy. (Magg, Reid & DiGangi, 1993) Self-monitoring of academic performance is effective in increasing academic productivity, accuracy, or use of strategies for students with learning disabilities, attentional difficulties, and behavioral disabilities. (as cited Shimabukuro, et al. 1999) Some E.nopi MATH students did not pay attention to accuracy of their answers. When students made mistakes,

they were asked to make corrections in their booklets. Some booklets had to be returned several times before the correct answers were given. Several students did not understand why they were asked to make no mistakes.

Concentration levels for students have improved since practicing with the program. All six teachers mentioned that their students began to concentrate better as the program progressed. Over time there was less talking and students remained in their seats as directed by the teachers. For most children aged six to seven years old, concentrating for 10 minutes is not easy. Concentrating on the work in the math booklets for 10 minutes every day was a good practice for the students.

Selecting a good regular time to do E.nopi MATH was also an important factor the program's success. Coming back from the playground after lunch is a transitional time for both the teacher and students, and a 10 minute period could be easily wasted before students get into studying mode. Having a systematic routine helps both teachers and students get on task fast, automatically. Doing E.nopi MATH after the lunch hour every day was the ideal opportunity. Doing computational practice only for 10 minutes made a difference for the first and the second graders. Both students and teachers welcomed the program and students said doing E.nopi MATH was fun, while teachers said the 10 minute quiet work period helped students easily transition to the next academic activity.

Children should be allowed to practice until they master the basic computational skills because understanding then mastering major basic concepts of mathematics may take longer than expected. Students should master addition and subtraction up to the automaticity level by the second grade according to NCTM's position (NCTM, 2006). The Wisconsin Department of Public

Instruction (2008a) recommends 250 minutes per week for math instruction and 700 minutes per week for reading and writing. To achieve the necessary level of automaticity with addition and subtraction computational skills, the school must provide sufficient time to practice using a well-organized program.

In Korea, most mothers help their children master computational skills at home. Classroom teachers do not spend much time helping students master basic math concepts. Students learn to understand the concepts at school and master them at home with the help of adults. In the U.S., the same kind of support from homes is not expected and is often not available; therefore, teachers should create time within each day to work with students to help them master basic addition and subtraction facts. Without systematic practice, students will progress through the grades without mastering the required basic skills. Mastering and understanding are not the same thing. To achieve the automaticity level of computational skills, students should master the skills as well as understand the concepts.

LIMITATIONS

One university charter school was selected for the project. Both the control and experimental group were chosen based on the availability of data from the previous year. All three first grade classrooms and all three second grade classrooms for the 2007-8 school year were utilized, and the first and second grades of 2006-07 were selected as the control group. This study assumes for research purposes that these are compatible groups; however, there is no way to be absolutely sure that the two groups are perfectly equivalent.

Another major problem of the research design is that the control and experimental group did not have the exact same amount of time doing math. The experimental group had 10 more minutes than the control group. Both groups were taught math using the Saxon Math curriculum, and only the experimental group had an additional 10 minutes computational practice. The experimental group had 10 minutes more of on-task benefit than the control group.

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