2005

Effective Thinking Strategies

Wendy Trainer
University of Northern Iowa

Effective Thinking Strategies

Abstract

The purpose of this study was to determine if teaching efficient thinking strategies would increase students learning of basic addition math facts as measured by timed tests, student interviews, interviews with teachers, and the districts basic facts data. Basic addition facts are facts that are a single digit plus a single digit. The efficient thinking strategies include "count on to add," use "doubles to add," and "make ten." The research suggests that basic facts need to be improved. Students should be reasoning, problem solving, communicating, and making connections in math to learn the basics. These strategies will .help students understand math better. Students need to recognize the importance of reflecting on their thinking and be able to learn from their mistakes. By using a variety of efficient thinking strategies such as counting on to add, using doubles to add, and making ten, students can improve on basic addition facts.

EFFICIENT THINKING STRATEGIES

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

Wendy Trainer

University of Northern Iowa

April 2005

This Research Paper by: Wendy Trainer

Entitled: Efficient Thinking Strategies

Has been approved as meeting the
research paper requirement for the degree of

Master of Arts in Education
Educational Psychology: Professional Development for Teachers

John E. Henning

Director of Paper

Victoria L. Robinson

Reader of Paper

Reader of Paper

John E. Henning

Advisor

John K. Smith

Department Head

5/6/05
Date Approved

TABLE OF CONTENTS

EFFICIENT THINKING STRATEGIES

INTRODUCTION

Purpose

The purpose of this study was to determine if teaching efficient thinking strategies would increase students learning of basic addition math facts as measured by timed tests, student interviews, interviews with teachers, and the districts basic facts data. Basic addition facts are facts that are a single digit plus a single digit. The efficient thinking strategies include "count on to add," use "doubles to add," and "make ten."

The research suggests that basic facts need to be improved. Students should be reasoning, problem solving, communicating, and making connections in math to learn the basics. These strategies will help students understand math better. Students need to recognize the importance of reflecting on their thinking and be able to learn from their mistakes. By using a variety of efficient thinking strategies such as counting on to add, using doubles to add, and making ten, students can improve on basic addition facts.

Children need to learn a variety of thinking strategies and be able to use them flexibly. Instruction promoting the use of thinking strategies will help students learn basic facts and is more effective than drill for speed, accuracy, memorization, and retention. Encouraging the use of thinking strategies helps students learn effective ways to solve basic facts. Students should develop thinking strategies for the fact and strategies for mental computation. The underlying assumption is that children benefit from having a variety of ways to understand a given concept. Building on their individual strengths and learning styles can make instruction more effective. Previous research showed that

memorization of facts should come after the meaning of the fact is understood. Everyone needs to understand mathematics and have the opportunity to learn efficient thinking strategies with understanding. The school in this study saw a need for students to learn basic facts based on interviews and timed tests.

An important concept in a first grade math curriculum is learning addition facts. By the end of first grade students are expected to be proficient on 100 addition facts with sums to 18 in 8 minutes. Teachers use many different methods to teach addition concepts and memorization of basic facts. This study will investigate whether teaching efficient thinking strategies, having weekly practice on addition facts, and administering timed tests will be an effective way to teach first grade students basic addition facts. Also, will using *Thinking With Numbers* cards and posing a fact of the week increase their speed and understanding on basic addition facts?

Significance

The research in this study was important because we all use our knowledge about basic facts to solve mental math situations on a daily basis. Learning efficient thinking strategies can help students learn basic facts quickly and accurately. Being able to recall basic facts quickly is an important math skill.

The findings for this study could be helpful because the evidence of success could prove beneficial to teachers. More methods are needed to develop thinking by students. Therefore, it is important to find out if the research will work in other classrooms as well as the classroom used in this study.

Limitations

Four limitations of this study should be noted. First, some students may not do well with the pressure of timed tests so the results may not be completely accurate. Second, when students were interviewed using word problems, some of the word problems involved subtraction and the students had not been taught subtraction thinking strategies at the time of the research. The third limitation is the number of participants. The study was limited to one first grade classroom with 22 participants. Fourth, students who were absent could have an effect on the study as well as students with limited English.

LITERATURE REVIEW

Introduction

A review of literature was completed to review the research supporting the basics in math. In order to continue in improving mathematics education, children, parents, and teachers must be better prepared. Many say we must get back to the basics (Burch & Spillane, 2003). The traditional basics are addition, subtraction, multiplication, and division. These basics need to be continued as well as the basics that are needed for the present and future. The basics should also include: reasoning, problem solving, communications, making mathematical connections, and collaborating. Mathematics instruction should develop children's thinking and reasoning abilities (Rathmell, 1994).

Research has shown that children learn strategies that work to improve skills (Rathmell, 1994). Three main points on how children can best learn, recall, and retain their mathematical facts have emerged from the literature. First, children need to be problem solvers. Second, strategies are discussed that work to improve computation fluency, and third, using efficient thinking strategies to teach basic facts. Children need to understand the meaning of arranging, counting, and manipulating and have meaningful experiences before memorization of facts should occur (Burns, 2002). In summary, the literature found these points necessary to learn, recall, and retain basic mathematical facts.

Effective problem solvers

An effective problem solver will question, find, investigate, and explore a solution to a problem. They understand that there can be several ways to get an answer and they apply

math to real-life situations. Problem solvers also apply what they have learned to new problems. According to Kirkpatrick, Swafford, and Findell (2001) problem solving and reasoning are the heart of mathematics.

Mathematical reasoning means students are using logic when explaining a solution to a problem. Children need to see similarities and differences in problems and be able to think about the relationship among them. Students will also listen carefully to understand others' way of thinking and reasoning (US Department of Education). Burns (2004) reports that too often teachers ask students to explain their thinking only when the answers are incorrect; however, it is important to ask for explanations all the time. Asking for explanations forces students to organize their ideas. Explaining their thinking will also give them the opportunity to develop and extend their understanding.

Children who make connections are engaged in mathematics and see mathematics as sensible, useful, and doable. Helping students make connections to other subjects can develop their knowledge of other subjects as well as knowledge of the applicability of mathematics. Conversations where mathematical ideas are discovered from different perspectives helps children sharpen their thinking and make connections (National Council of Teachers of Mathematics Principles and Standards, 2000). Students who communicate mathematically use mathematical language, numbers, charts, and symbols to explain the reasoning for solving a problem.

Students need to be encouraged to justify their reasoning and also listen to explanations by others to make sense of mathematical concepts. By doing this students will develop an understanding of concepts to the solution of the problems. They will also

develop flexible problem solving strategies and have greater confidence in their ability to think mathematically. According to Pratt (2002) children need to apply their thinking in a mathematical context to be able to learn mathematical thinking. The math curriculum should be rich in problem solving and active learning. Children will also benefit from a more broadly enriched environment in which they see math being used in different ways.

Courey, Finnelli, Fuchs, Fuchs, & Hamlett (2003) suggests that by broadening children's schema will help with problem solving. Broadening schema will also help children recognize real-life math problems as solvable. A curriculum that focuses on the importance of mathematics will get students ready to solve problems in a variety of settings.

Solving problems in math requires students to be proficient at thinking critically, computing, and using a process to solve problems. Students need to be in an environment that conveys a message that math is important and fun. Using hands-on manipulatives and visual aids to stimulate thinking and connect learning to experiences in the real world will strengthen student's understanding of math concepts and skills (Forsten, 1992). Students, who are motivated, approach word problems with confidence. Forsten (1992) also encourages teachers to make problem-solving fun. Students need to see an interest and commitment to solving problems as well. Students need to be effective problem solvers and learn computational strategies.

Computational strategies

Mathematical literacy is having procedural and computational skills as well as conceptual understanding. Russell (2000) described students that are computationally

fluent have the ability to compute accurately, efficiently, and flexibly (Rathmell & Gabrielle, 2003). When students use flexibility in math they are making choices about what strategy would be most useful when solving a problem and understanding why the strategy was appropriate to use. When students exhibit computational fluency in addition, they can efficiently and accurately compute answers to an addition problem, use a variety of thinking strategies such as "counting on," "doubles," and "making ten" to compute answers, and they can monitor their work to make sure the answers are accurate and reasonable. As students make sense of thinking strategies they develop better computational fluency. It is important to provide students with a variety of computational strategies from which to choose.

In order to develop number sense and fluency of procedural skills, students need many opportunities to solve problems. These opportunities should be done throughout the year instead of just during one unit on solving problems. Teaching strategies will not work if the strategies are only used now and then (Forsten, 1992). Short and frequent practices are better than long drawn out practices. Long-term retention occurs when a particular skill is spread out (Suydam, 1985). Suydam (1985) also suggests short intensive review is better than long periods. As fluency with thinking strategies improve, students learn basic number combination.

Research has established the role of conceptual understanding in learning mathematics (Rathmell & Gabrielle, 2003). Factual knowledge and procedural proficiency along with conceptual knowledge will allow students to become effective learners (NCTM's Principles and Standards, 2000). NCTM's Principles and Standards (2000) suggest when

children have an understanding of numbers they will learn and recall computational procedures with ease. When students have computational fluency they should be able to explain, understand, and see the usefulness of the method being used (NCTM's Principles and Standards, 2000). However, Shellard (2004) agrees that students need to understand a skill or concept before being asked to practice it.

Basic facts

Basic additions facts are facts that are a single digit plus a single digit (Rathmell, 2000). Students need to learn basic facts to be able to use the operation with bigger numbers. Students who know basic facts can solve computation problems with bigger numbers in order to compute mentally (Rathmell, 2000). Shellard (2004) believes that students struggle in math because they are not able to see the larger picture, make associations, or remember basic facts. When teaching the basics such as addition, it is important to understand the meaning before the procedure (Shellard, 2004).

Children are able to reason better when they know the basic facts. Math processes like mental computation are based on recall of math facts. These processes can give students confidence to be problem solvers. Students who have meaningful experiences using math facts lay a foundation for mastery (Waite-Stupiansky & Stupiansky, 1998). When children are engaged in activities that use addition and subtraction, it gives them the opportunity to solve problems over and over. This helps them understand the consistency of facts. Efficient thinking strategies should be emphasized to help students learn basic facts. When using addition, students should realize and apply thinking strategies for doubles, making 10, adding 0, and adding 1.

A strong foundation in number sense is important to learning basic facts (Waite-Stupiansky & Stupiansky, 1998). According to Rathmell (2000) students who learn thinking strategies will be likely to develop good number sense and understand computation of all types. Memorization of facts should come after the meaning of the fact is understood. It is important not to hurry children into memorizing facts because they might rely on memory instead of logical skills (Waite-Stupiansky & Stupiansky, 1998). Number sense is important because students need to understand what numbers mean, how they can be used, various ways they can be represented, and the meaning of the operation or number.

Providing daily mental activities and warm-ups is a great way to build vocabulary concepts and skills. Problems of the day or week are effective ways to begin math time. Learning basic facts is important, but should not be the ultimate goal of instruction. Teachers of math do need to make sure that students are not memorizing meaningless strings of numbers, but that they understand the meaning behind the symbols (Waite-Stupiansky & Stupiansky, 1998).

Drilling children on basic facts and administering timed tests is not always viewed as positive (Waite-Stupiansky & Stupiansky, 1998). Teachers are encouraged to have a math curriculum with problem solving, manipulative and active learning, yet according to Waite-Stupiansky and Stupiansky (1998) mastering basic facts is important in a child's math education. Waite-Stupiansky and Stupiansky (1998) state that children who know the basic facts can reason more quickly and flexibly. Rathmell (2000) claims that drill and practice are not sufficient to learn basic facts. He suggests learning thinking strategies is a

more efficient way to figure facts out. Teaching efficient thinking strategies will help students learn facts more quickly and remember them better.

The goal for teaching basic facts is for students to have an immediate response and be able to justify the answers by explaining why the fact is correct (Rathmell, 2000). According to Rathmell (2000) students should be able to solve facts in about 3 seconds. Some students will be faster than 3 seconds, but teachers should be realistic about the amount of time they want students to solve basic facts. If not, teachers will be setting students up for failure. When children have positive attitudes toward mathematics and use thinking strategies and reasoning skill, they develop true mathematical power (Rathmell, 1994).

METHODS

Introduction

The purpose of this study was to see if teaching efficient thinking strategies will increase students learning of basic addition math facts as measured by timed tests, student interviews, interviews with teachers, and the districts basic facts data. This study utilized four measures to find out if teaching efficient thinking strategies increased the student's basic addition math facts. Teachers were interviewed to find out if basic facts are a concern and if the strategies taught and used in first grade will help students achieve efficient thinking strategies to increase basic facts. Students were interviewed to see what strategies, if any, they were using to solve problems. Timed tests were given to find out if students were using efficient thinking strategies to learn basic facts and if their speed increased.

Setting

Jewett Elementary is located in Evansdale, IA. Jewett is a part of the Waterloo Community School District. Jewett Elementary educates approximately 340 students in grades Kindergarten through fifth. A first grade class from Jewett was used in this study. The class is made up of 22 students. The first grade class was chosen because the teacher doing the research wanted to see increased scores on basic addition facts. The first grade students in this study are taught math lessons at the "calendar" floor, the carpet, and at student desks. Hands-on activities are used and efficient thinking strategies are taught on a daily basis. No students are pulled from the classroom during this time. The study was conducted over a six-month period.

Participants

Students

The participants in this study are 22 students in a first grade classroom attending Jewett Elementary. There are 11 boys and 11 girls. The cultures represented are American (12 students), Mexican-American (5 students), Bosnian (4 students), and African-American (1 student). With the high number of diverse students and English Language Learners (ELL), Jewett Elementary is able to appreciate, understand, and respect diversity. Two of the Mexican-American students and two of the Bosnian students are able to utilize the interpreters that are employed at Jewett. The students receive help in Reading and Math on a daily basis. The interpreters also translate notes and make phone calls to keep parents informed and involved with what their child is doing at school.

Teachers

The participants of the interview are three teachers currently employed by Jewett Elementary. The first teacher interviewed is a current third grade teacher. The second and third teacher interviewed are teaching fourth grade.

Measures/Instruments

Three-minute timed test

Students were given weekly practice sheets on basic addition facts with sums through 12. There were 30 vertical addition problems and students were given three minutes to complete the problems. The students were asked questions daily from *Thinking with Numbers,* which students solve word problems using basic facts aloud. Students spent two to three minutes daily doing this activity during calendar time. The students were also

given a fact of the week to solve. The fact was displayed on the board so the students could solve it every time they walked by. Once a month a three-minute timed test was given and students' results were recorded.

The purpose of the three minute timed test was to make decisions on student's mathematical thinking and to see if they had learned basic addition facts quickly. This measure will contribute to the personal analysis of the classroom to see if teaching efficient thinking strategies will increase the basic addition fact scores of the participants in this study.

Student Interview

The purpose of the interview was to see which questions on the interview were answered correctly, what strategy the student used and how they represented the math problem. Possible strategies in this interview included count all, count on, count back, use of a known fact and other. Students could represent the math problems by using their fingers, counters, drawing a picture, solving it mentally, or other. The interview also included the math language each student was using, but for this study it was eliminated. It was eliminated because this study was mainly interested in strategies used and how they were represented. The questions on the interview consisted of ten addition and subtraction facts. The interview questions and assessment summary were developed by *Thinking With Numbers Inc.* (See Appendix A.) The students thinking strategies and representations were recorded to gain information on their thinking.

Teacher Interview

An interview was conducted in September 2004 with teachers who taught fourth grade

during the 2003-2004 school year. The exact wording and sequence of questions were determined in advance. All interviewees were asked the same basic question in the same order. Questions were worded in an open-ended format. The original purpose of the interview was to compare math strategies and curriculum used from October 2003 to April 2004.

District timed test

The Waterloo School requires a basic addition fact timed test be given during the sixth week of the second quarter. Another required basic addition timed test is to be given during the eighth week of the second quarter. The first timed test consists of 21 vertical addition problems with sums to six. The students are given three minutes to complete the timed test. The second timed test consists of 45 vertical addition problems with sums to 10. The students are given five minutes to complete the timed test.

The purpose for these assessments was to see the percentage of students who were proficient. The district requires students to receive 80% or higher to be proficient. This measure will contribute to the study to show the percent of proficient students on basic addition facts and will show if using strategies for teaching basic facts are based on understanding rather than on rote memorizing.

Procedures

Three-minute timed test

At the end of August a math pretest was given to the first grade students. The pretest consisted of 30 vertical addition problems with sums through 12. Students were advised that they might not know all the answers on the worksheet or get finished. It was made

clear to the students that they would be taught how to do the problems on the worksheet and that they would be tested again throughout the year. The three minute timed test was administered once a month, and data was collected for six months.

Each student was given a worksheet with 30 addition facts. The students put up an "office." An office is hand made and consists of two folders taped together to form an office that goes around their paper so other students cannot see the papers of other students. The students were then instructed to put their name and date on the paper and then hold their pencil in the air. When the teacher said, "start" the students could complete the timed test. When the teacher said, "stop" the students were instructed to put their pencil in the air again. The tests were collected and the baseline was set for analysis. Weekly practices were also given to students on addition facts. Monthly timed tests were given and collected for data. It was made known to students that it is their personal improvement that counts when taking timed tests.

Student Interview

In August, each student was called over to a table in the back of the room to be interviewed using word problem questions over basic facts. Materials such as paper and pencil and counters were available if the students desired. The students were also allowed to use their fingers, if necessary. The students were made comfortable before starting the interview. Each student was told that they might not know the answers to all the questions and that they would be learning how to solve the problems throughout the year. A problem was then presented and the student was observed as they solved and explained their thinking strategy. After the interview, each student received a math sticker that

included a positive math saying. Each interview in August took about five minutes per student. The results for each student were recorded on the student interview sheet and a graph was completed to see what strategies and representations were being used (See Appendix C.) The same procedure using the interview questions was used again in January. The interview took about ten to fifteen minutes per student to complete. The information from the interview was recorded on the student interview sheet and a graph was completed to see what strategies and representations students were using in January (See Appendix D.) Results can be compared from the August interview to the results from the January interview. The information on the graphs shows what strategies the students are currently using and what strategies the students should be encouraged to use. A graph was also completed to show the number of correct responses for each question. Results can be compared from the August responses to the January responses (See Appendix E.) The results will also be shared and discussed with parents during February conferences.

District Timed Test

During the sixth week of the second quarter, students were given a timed test using the school districts required timed test. Each student put up an office and were instructed to write their name and date on the paper and put their pencil in the air and when the teacher said "begin" the students had three minutes to complete 21 vertical addition problems with sums to six (See Appendix F.) During the eighth week of the second quarter another required timed test was given using the same procedures that were used during the sixth week. This timed test consisted of 45 vertical addition problems with sums to 10 (See

Appendix G.) The students were allowed five minutes to complete the test. Students were given praise for correctly answering the problems they tried. The students were made aware that speed and accuracy is the goal.

The student's scores were recorded with percent correct and transferred onto the districts form. The results were then graphed to show a visual of how many students were proficient. The district requires students to receive 80% or higher to be proficient. The scores were then reported to the principal. Teachers and principal examined individual student scores and noted their progress throughout this study

Teaching Method

The majority of students need lots of practice in learning their facts. Teaching the strategies and doing activities with the students began mid September and will continue throughout the year. Students were taught efficient thinking strategies on a daily basis. The efficient thinking strategies that were taught for the purpose of this study were count on to add, use doubles to add, and make ten. The focus is on accuracy and speed or efficiency and to think about what strategy will be most useful in solving the problem. Students are expected to monitor their work for accuracy and reasonability of their answer.

A fact of the week was also displayed so each time students passed by it they could give the answer. At the beginning of each week a pre-determined addition fact was written on the chalkboard. The addition fact was discussed and it was determined by the class which strategy would be the best to use in order to solve the problem.

The teaching intervention assessed the student's mathematical thinking. The

intervention will analyze the students' use of math strategies. Students' growth in basic facts will be monitored to see how many students are proficient after each timed test. Specific strategies for quick recall are taught in first grade. Some students can easily memorize facts, while other students need the help of a strategy to recall basic fact answers.

Students were observed during the weekly practice tests to see what strategy they were using to solve the addition problems and to see which students had memorized the facts. Notes were taken about each student's strategy and conceptual understanding and their ability to compute fluently.

The students were also given the opportunity to use computer programs to help them with basic math facts. The computers were available on a 15-minute rotation during center time. Students were also able to use flashcards during this rotation. They were instructed on how to drill each other. Also, as a class we played "Around the World" using flashcards so students had experiences giving quick oral answers. Around the World is a game in which students sit in a circle. The student who is chosen to start and then stands behind a student sitting in the circle. The teacher is in the middle of the circle holding addition flashcards. The teacher makes sure the two students are ready and then flashes them a card. If the student standing says the correct answer first, then they advance to the next student. If the student sitting says the correct answer first, they stand up and take the place of the person standing and advance to the next person. The student standing would sit in the spot of the student sitting in the circle. The object of the game is to be accurate and fast.

Each day at calendar floor a word problem was posed from *Thinking With Numbers* (See Appendix B.) The questions helped the students learn how to efficiently count on to add, use doubles to add, and make ten to add. The students were then given the opportunity to think about the problem and then share how they came up with their answer. The teacher highlighted the students thinking strategy by repeating the strategy the student used. At times manipulative were used to concretely model the solution

RESULTS

Introduction

The purpose of this study was to see if teaching efficient thinking strategies increased student's ability to learn basic addition math facts. Students felt more confident when taking timed test. The practice gave them the confidence to complete the timed test. They seemed excited when they were shown the scores and how they had improved. As the thinking strategies improved, frustration decreased as indicated by interviews and the timed tests.

The results of the data collected show that students made growth in using efficient thinking strategies. There is also an increase in percent of addition facts answered correctly. The growth may be contributed to the approaches that were used to teach basic facts. Although the data showed progress, students will need to continue to practice on basic addition facts to maintain their steady progress and speed.

Three-minute timed test

Students had no practice when the timed test was administered in August. It was noted that there was frustration among many of the students as they tried to complete the timed

test. They were reassured that it would get better and as time passed and they were given opportunities for practice, it became a more enjoyable experience for everyone! As efficient strategies were taught the results show how students improved in basic addition facts each month. (See Appendix H.)

August results show that not many students' knew basic facts or the strategy to solve them. Zero students scored 100%. One student received 97%. This student had been retained and also attended the 2004 summer school. Most students show a slight increase at the end of September, keeping in mind students had only been learning the strategies for about two weeks. The months that follow also show an increase in student's scores. In November, two of the students that are still showing minimal improvement and are still using time-consuming strategies to get the answer with little accuracy. These students are also ELL students who are being serviced by an interpreter (See Table 1.) The pretest showed a need to learn the basics for adding as well as efficient thinking strategies for addition. The following test results show an increase in the test scores from the August pretest to the January posttest for the targeted first graders (See Appendix I.)

Twelve out of the 22 first graders consistently scored 100% from November 2004 to January 2005. 19 out of the 22 students increased their scores each month. Only one Student's score decreased in January after improving each month. This was due to many of his answers being one number higher than the correct answer.

Table 1

Three-minute timed test on basic addition facts by percentage - shows increases in student scores from August 2004 - January 2005.

student	8/30/2004	9/30/2004	10/30/2004	11/30/2004	12/20/2004	1/28/2005
CB	30	73	90	100	100	100
EC	10	17	100	100	100	100
MC	0	3	10	40	50	53
BC	13	27	100	100	100	100
JD	0	0	73	83	90	100
DD	20	93	100	100	100	100
NG	20	33	70	80	97	100
ZG	3	47	97	100	100	100
AG	0	30	100	100	100	100
DI	27	50	87	100	100	100
JK	0	0	83	100	100	100
DK	23	63	87	100	100	100
NL	7	33	87	87	90	100
CM	0	0	57	73	83	97
NM	0	3	20	30	30	57
ZM	3	67	100	100	100	100
GO	0	7	17	23	87	73
AS	0	3	27	53	67	83
CV	0	27	63	100	100	100
LV	97	100	100	100	100	100
SV	0	0	3	3	43	43
KZ	0	0	13	13	33	43

Student Interview

The pretest administered in August showed a need to learn the basics for adding as well as learning efficient thinking strategies for addition and subtraction facts. The students did not use strategies efficiently to solve word problems. They mainly represented the math problems by using their fingers, counters, or by drawing pictures

with no accuracy. However, the interviews in January showed students had learned and were using the thinking strategies to solve basic facts. The representation moved from most students using fingers, counters and pictures to mentally solving the problem.

Several students made confident remarks during the interview. Examples of remarks made were "This is easy" and "I know what strategy to use." The remarks indicate they are responding more quickly and accurately. The students showed enthusiasm each day at calendar floor waiting for a word problem to solve. They were excited when the names in the word problems were replaced with the names of students in the class. The students learned different thinking strategies and were asked, "What strategy did you use?" They were able to verbally explain it. It is believed students learned from their peers as they explained how they got the answer to the word problems. Having an explanation and modeling the answer gave the students an effective way of learning. Satisfying and encouraging responses were heard from students referring to other students who figured out strategies. They would respond with, "he/she is thinking now" or "good job."

Teacher Interview

During their interviews, teachers stated that learning basic facts is a major goal they want to accomplish. All teachers interviewed used basic fact practice when teaching math. Teacher two says by laying down the foundation of basic facts, students would find new and different concepts a little easier. Teacher three says along with basic facts, her goal was to do more pre/post testing to align instruction. The teachers have concerns about not having enough time to collaborate. Since the interview were with new teachers or teachers new to the building, it is apparent more training and communication is

needed. The teachers made math fun and interesting by using manipulative, flash cards, and games in their lessons. The teachers seem to enjoy teaching math and want to make it an enjoyable experience for their students (See Appendix J for entire interview questions.)

District Timed test

Students had many learning experiences and practices on basic addition facts prior to the three-minute timed test administered the sixth week of the second quarter. All 22 students in the first grade classroom were tested on 21 facts with sums to 6 in three minutes. 20 out of 22 students finished before the three-minute time. Eighteen out of the twenty-two students were proficient using the 80% proficiency scale set by the district (See Table 2.)

Table 2

District Addition Timed Test - Quarter 2 - Shows scores of students who are proficient at 80% or above. 81% of the students were proficient on week 6 and week 8.

Week 6	Week 8
38	29
67	53
71	29
71	60
90	80
90	91
90	93
90	100
90	100
95	100
100	96
100	98
100	98
100	98
100	100
100	100
100	100
100	100
100	100
100	100
100	100
100	100

Two of the students who were not proficient and did not finish before the three minute time are still using time consuming strategies, but with more accuracy. It was noted that the other two students who were not proficient and finished before the three-minute time hurried through the test with some accuracy. Six of the students that were proficient scored 90% or higher and twelve scored 100%. The percent of students proficient on the three-minute timed test was 82% of the first grade class.

The second district timed-test shows 22 students in the first grade classroom were tested during week eight of the second quarter over 45 addition facts with sums to 10 in five minutes. Eighteen out of the twenty-two students were proficient using the 80% proficiency scale set by the district. The same students who were not proficient on the first district time-test were the same students who were not proficient on the second district time-test. Similar observations were observed and noted from the students who were not proficient. One of the students scored 80% while six of the students scored 90% or higher. There were eleven students who scored 100%. (See appendix K for complete results).

Discussion

The purpose of this study was to see if teaching efficient thinking strategies increased students learning of basic addition math facts. The results of this study showed an increase in participant's basic addition math facts scores. Students used the efficient thinking strategies that were taught with success. The information gained from the timed tests and interviews were used for planning instruction. In general the students liked learning the strategies and liked seeing the improvement that was made when their scores

were discussed with them.

Teacher perception of this study is that there was a positive effect on scores due to the approach that was used. A thirty to fifty minute practice session over basic facts is not as effective as three to five minute practice sessions throughout the week. When these approaches are used three to five minutes a day throughout the school year, the results showed improvement in student's scores. Students who receive repeated opportunities to solve problems and who get to listen to others strategies being explained seems to be the most likely way for them to achieve the understanding necessary for them to retain the skill. The way they represented the word problems went from time consuming representations of drawing pictures, and using counters or fingers to the use of mental representation.

The results from the teacher interviews showed a need for students to learn and understand basic facts in the early grades. The successful results of the District Basic Fact Data from the first grade classroom showed basic facts improved from August 2004 to January 2005. Timed tests did not help students learn thinking strategies, but did encourage students to speed up their thinking. Offering students' opportunities to learn efficient thinking strategies showed that scores and student confidence improved. The results of this study should be reported to the students, parents, teachers, and administrators. They should be excited by the results and be encouraged to try these approaches in the classroom and at home.

Based on the experiences from this research, it is recommended that other teachers use the approaches in this study. As results are shared and discussed with other team

members it is recommended that the math spokesman from the building share the results with the curriculum director during their meetings. Jewett Elementary along with the entire district is interested in ways to improve scores and the success of students. It is believed that the approaches are working due to the efforts of the teachers and participants. The interpreters do a great deal of work with the two ELL students who are showing only slight increases in scores. Time is needed for these students to efficiently learn the strategies in order to get accuracy as well as speed. They have a lot to learn and transfer throughout the day. Parents are encouraged to practice at home since basic facts can be translated in any language.

From this study, it is believed that before a fact strategy becomes automatic, students must develop the mental habit of using an appropriate strategy for a fact that pops up in a non-drill situation. Frequency of practice is important. If a child only practices once a week, little long-term learning will take place, however, by practicing a little every day it should certainly make a difference in their ability to recall basic facts quickly. Repeated practice seems to improve this skill. Students who have been successfully using efficient thinking strategies seem to be able to improve on computation problems as well.

Although the data showed progress, students will need to continue to practice on basic addition facts to maintain the steady progress and speed. Mastery of basic facts in first grade involves the quick recall of basic fact answers. This means all students need to recall an answer without relying on time-consuming strategies such as finger counting or drawing pictures. The goal of the Waterloo School District is by the time students exit 5th grade; they should have basic facts committed to memory. Students who have automatic

access to basic facts are free to spend more mental processing on problem solving and are more likely to become successful problem solvers.

It is recommended that teaching efficient thinking strategies with subtraction should be the next step. There is no data using the participants from this study that show this strategy will work with subtraction as well as it did with addition. Based on the discussions with colleagues, and the success from this study, the thinking strategies should be used for other basic facts as well. Students should also be encouraged to plan strategies for improvement. For example, students might say one way for them to improve would be to practice their facts through five tonight or they will agree to spend 10 minutes a night on their flashcards.

Further study is also recommended to see what impact summer vacation has on the thinking strategies. Will students revert back to counting their fingers to solve many of the basic facts? Will they maintain their speed and accuracy on scores and be able to solve them mentally? Children learn many strategies to help them master facts, but practice is essential to master the process.

First graders are eager learners and teachers should continue to build self-confidence, nurture curiosity, and challenge students with problems through which they will come to value math.

References

Burch, P. & Spillane, J.P. (2003). Elementary school leadership strategies and subject matter: reforming mathematics and literacy instruction. *The Elementary School Journal, 103*, 520-534.

Burns, M. (2002). Q & A with Marilyn Burns. *Instructor, 111,* 21-24.

Burns, M. (2204). 10 big math ideas. *Instructor, 113*, 16-19.

Courey, S.J., Finelli, R., Fuchs, D., Fuchs, L.S. & Hamlett, C. (2004). Expanding schema-based transfer instruction to help third graders solve real-life mathematical problems. *American Educational Research Journal, 41*, 419-445.

Forsten, C. (2004). The problem with word problems. *Principal (Reston, Va.), 84*, 20-23.

Kilpatrick, J., Swafford, J. & Findell, B. (2001). Adding it up: Helping children learn mathematics. *National Academy Press, Washington, D.C., 165*, 18-21.

National Council of Teachers of Mathematics. (2000). The executive summary of principles and standards for school mathematics. Retrieved February 12, 2005, from NCTM web site: http://www.mctm.org/standards/overview.htm

Pratt, N. (2002). Mathematics as thinking. *Mathematics Teaching, 181*, 34-37.

Rathmell, E.C. (1994). Planning for instruction involves focusing on children's thinking. *Arithmetic Teacher, 41*, 290-292.

Rathmell, E.C> (2000). Basic facts: Questions, answers, and comments. Retrieved February 22, 2005 from http://www.math.uni.edu/134/content/basicfactsagenda.html

Rathmell, E.C. & Gabriele, A.J. (2003). Developing Computational Fluency Number and Operations. Unpublished manuscript.

Shellard, E.G. (2004). Helping students struggling with math. *Principal (Reston, Va.), 84,* 40-43.

Suydam, M. (1985). The role of review in mathematics instruction: ERIC/SMEAC Mathematics Education Digest No. 2. (ED 260891)

U.S. Department of Education. Helping your child learn math. Retrieved February 12, 2005 from ED.GOV web site: http://www.ed.gov/pubs/parents/Math/index.html

Waite-Stupiansky, S. & Stupiansky, N.G. (1998). Don't forget the facts. *Instructor-Intermediate, 108,* 82.

APPENDICES

Appendix A

1. John has 9 video games. He loaned 3 to Rachel. How many did he still have?

answer	time	strategies	representations	math language	comments
		count all count on count back use a known fact other	fingers counters draw a picture mental other	join take away plus minus add subtract	

2. Kenny has $6. His mother gave him $2 more. How much money does Kenny have now?

answer	time	strategies	representations	math language	comments
		count all count on count back use a known fact other	fingers counters draw a picture mental other	join take away plus minus add subtract	

3. Sarah has 4 green shirts and 5 blue shirts. How many shirts does she have in all?

answer	time	strategies	representations	math language	comments
		count all count on count back use a known fact other	fingers counters draw a picture mental other	join take away plus minus add subtract	

5. Anne has 5 stickers. Tina has 8 stickers. How many more stickers does Tina have than Anne?

answer	time	strategies	representations	math language	comments
		count all count on count back use a known fact other	fingers counters draw a picture mental other	join take away plus minus add subtract	

. Eric put 10 fish in the school aquarium. Adam put in 7 fish. How many fish did the two put in the aquarium?

answer	time	strategies	representations	math language	comments
		count all count on count back use a known fact other	fingers counters draw a picture mental other	join take away plus minus add subtract	

6. Brad had 16 candy bars. He gave some to his friends. Now he only has 8 left. How many did he give away?

answer	time	strategies	representations	math language	comments
		count all	fingers	join	
		count on	counters	take away	
		count back	draw a picture	plus	
		use a known fact	mental	minus	
		other	other	add	
				subtract	

7. Tara has a toy box with 24 dolls in it. She gets 10 more dolls and puts them in the box. How many dolls are in the box?

answer	time	strategies	representations	math language	comments
		count all	fingers	join	
		count on	counters	take away	
		count back	draw a picture	plus	
		use a known fact	mental	minus	
		use tens	other	add	
		other		subtract	

9. Tyler has 35 crayons. Allison has 32 crayons. How many fewer crayons does Allison have?

answer	time	strategies	representations	math language	comments
		count all	fingers	join	
		count on	counters	take away	
		count back	draw a picture	plus	
		use a known fact	mental	minus	
		use tens	other	add	
		other		subtract	

9. Ben and Matt each collected 26 aluminum cans. How many cans did both boys collect?

answer	time	strategies	representations	math language	comments
		count all	fingers	join	
		count on	counters	take away	
		count back	draw a picture	plus	
		use a known fact	mental	minus	
		use tens	other	add	
		other		subtract	

10. What is the total? $3 + 7 + 8 + 2$

answer	time	strategies	representations	math language	comments
		count all	fingers	join	
		count on	counters	take away	
		count back	draw a picture	plus	
		use a known fact	mental	minus	
		use tens	other	add	
		other		subtract	

Examples of count on to add, use doubles to add, and make ten to add using the Thinking With Numbers cards.

Count on to add-

Problem – In the town of Evansdale, it rained 6 inches yesterday. Today Evansdale received another inch of rain. How many inches of rain did Evansdale receive in the last two days?

Connections - Highlight a count on explanation. Have students try it with the following problem:

Suppose Evansdale got 3 inches of rain yesterday and 2 more inches today. How many inches did they get in the last two days?

Use doubles to add-

Problem – Jessica and Austin each ate 4 slices of pizza. How many slices did they eat altogether? If Austin eats one more slice, how many slices will they have eaten in all?

Connections – Highlight a doubles explanation. Have all students try it with:

Suppose Jessica and Austin each ate 5 slices of pizza. If Jessica decides to eat 1 more slice, how many slices will they have eaten in all?

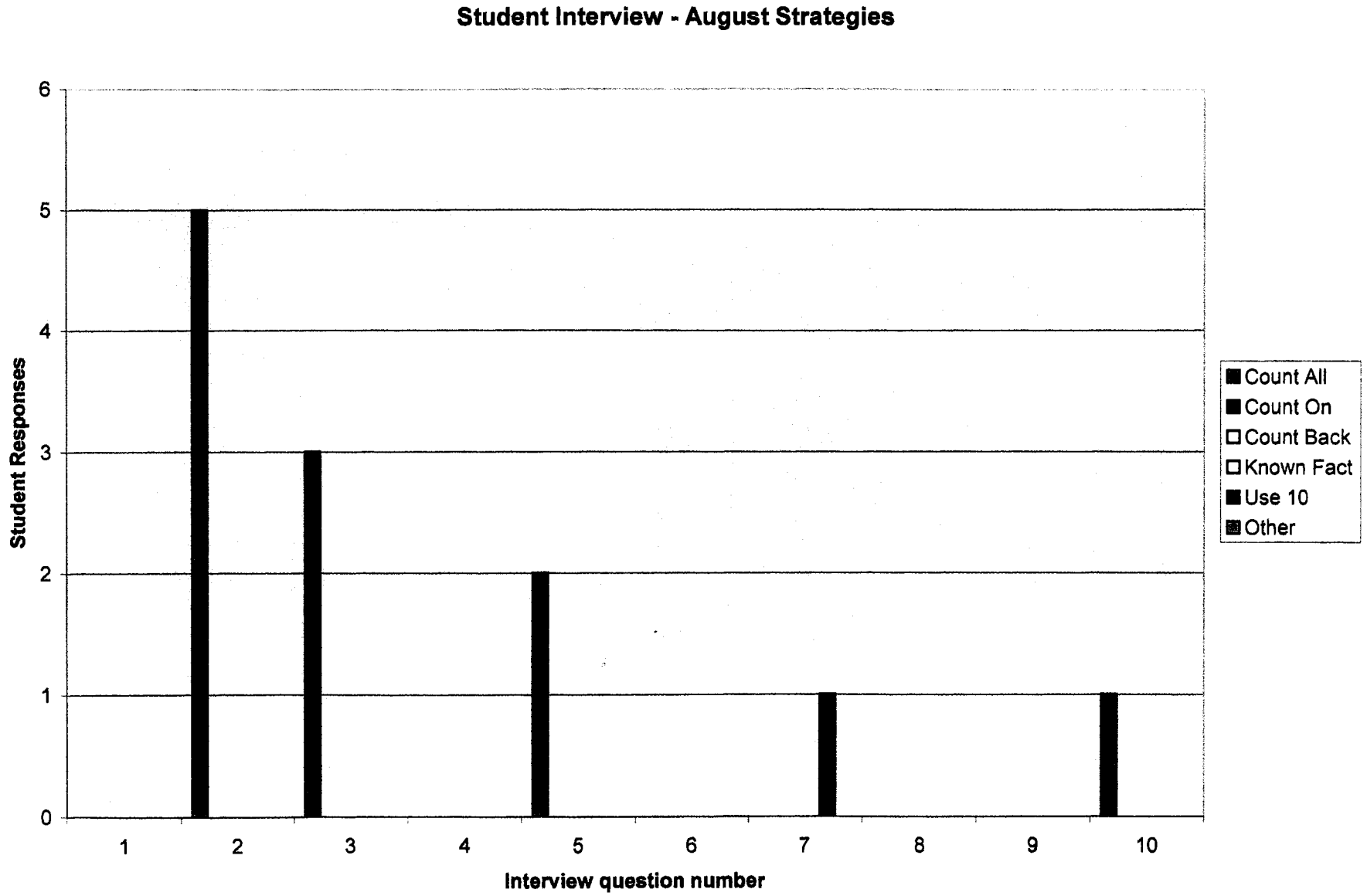
Make ten to add –

Problem – Zaira and Cecilia bought gumdrops last night. Zaira ate 9 pieces and Cecilia ate 5 pieces. How many pieces did they eat last night?

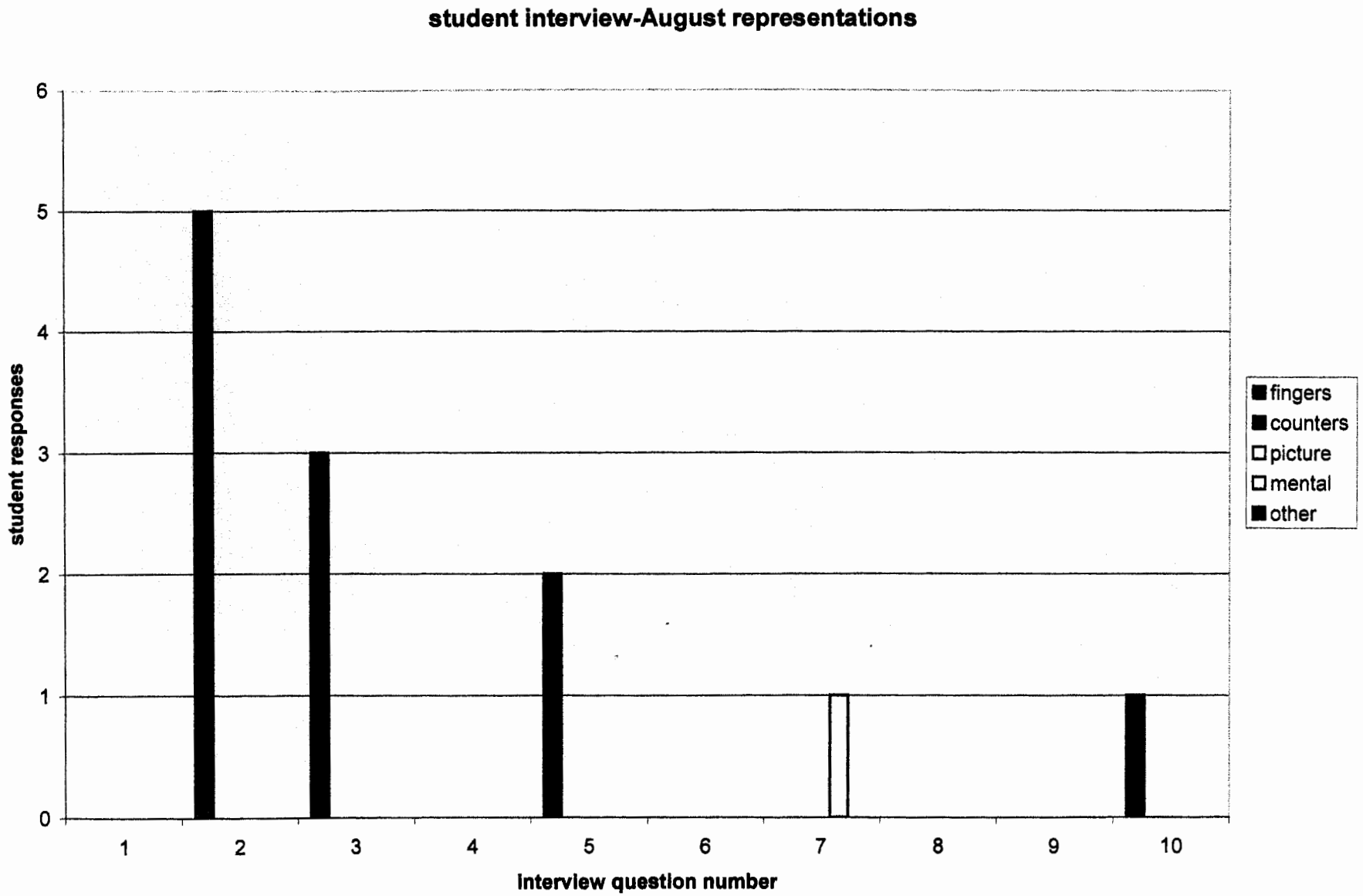
Connections – Highlight a make ten explanation. Have all students try it with:

If Zaira has 9 gumdrops and Cecilia has 7, how many gumdrops do they have altogether?

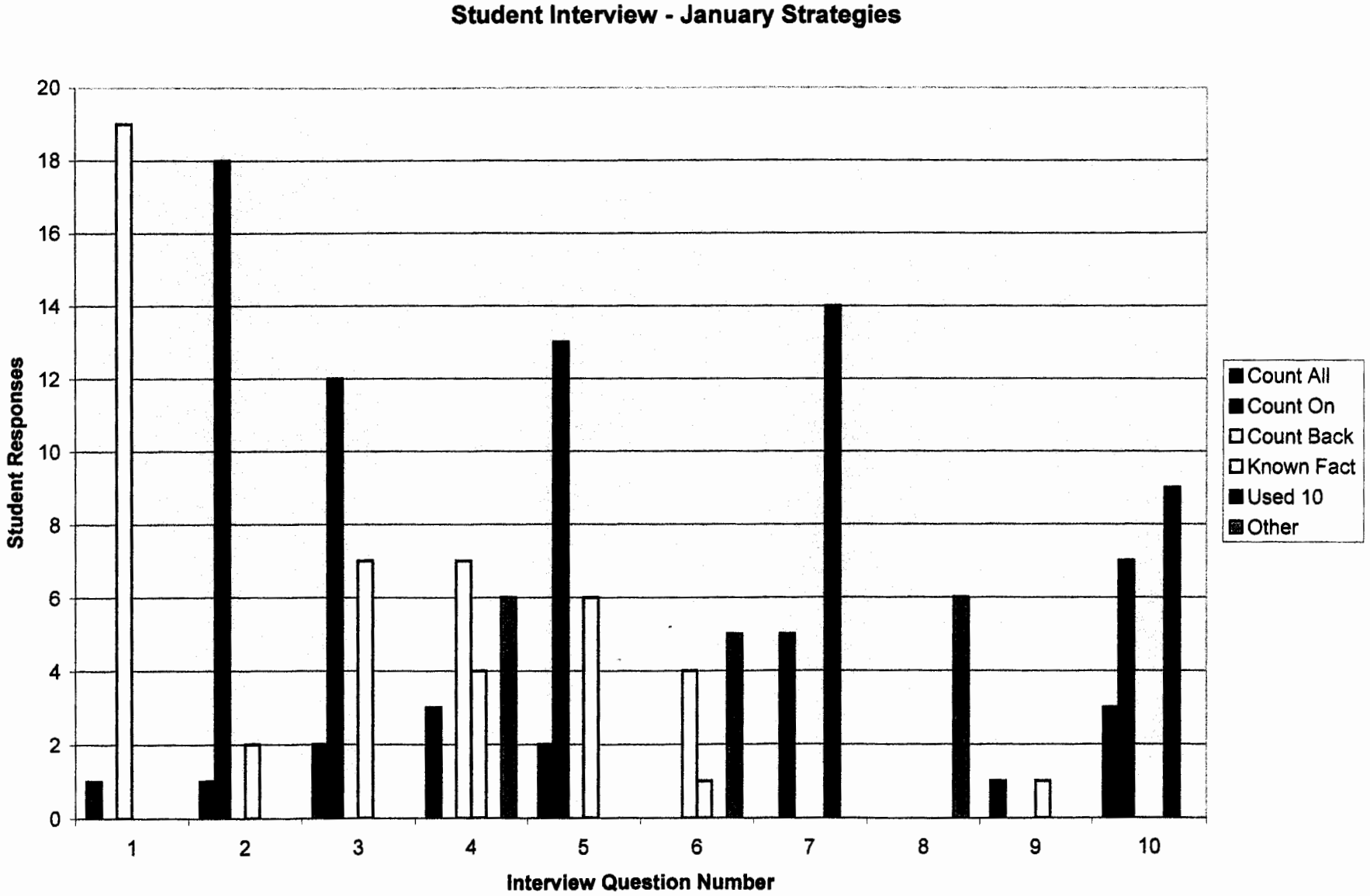
Appendix C


Student Interview - August Strategies
Student Responses
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
Interview question number
Count All
Count On
Count Back
Known Fact
Use 10
Other

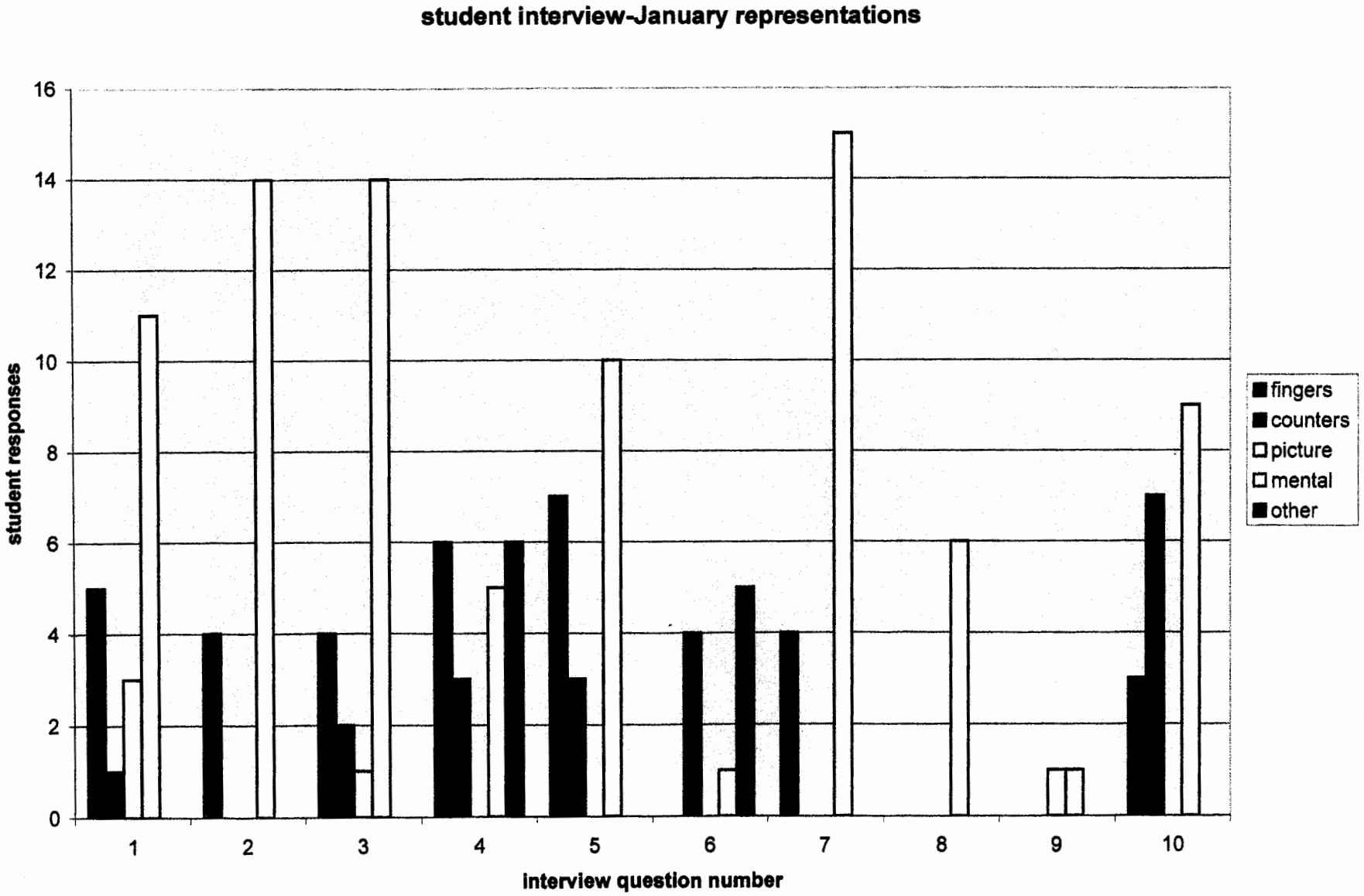
Appendix C


student interview-August representations
student responses
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
interview question number
fingers
counters
picture
mental
other

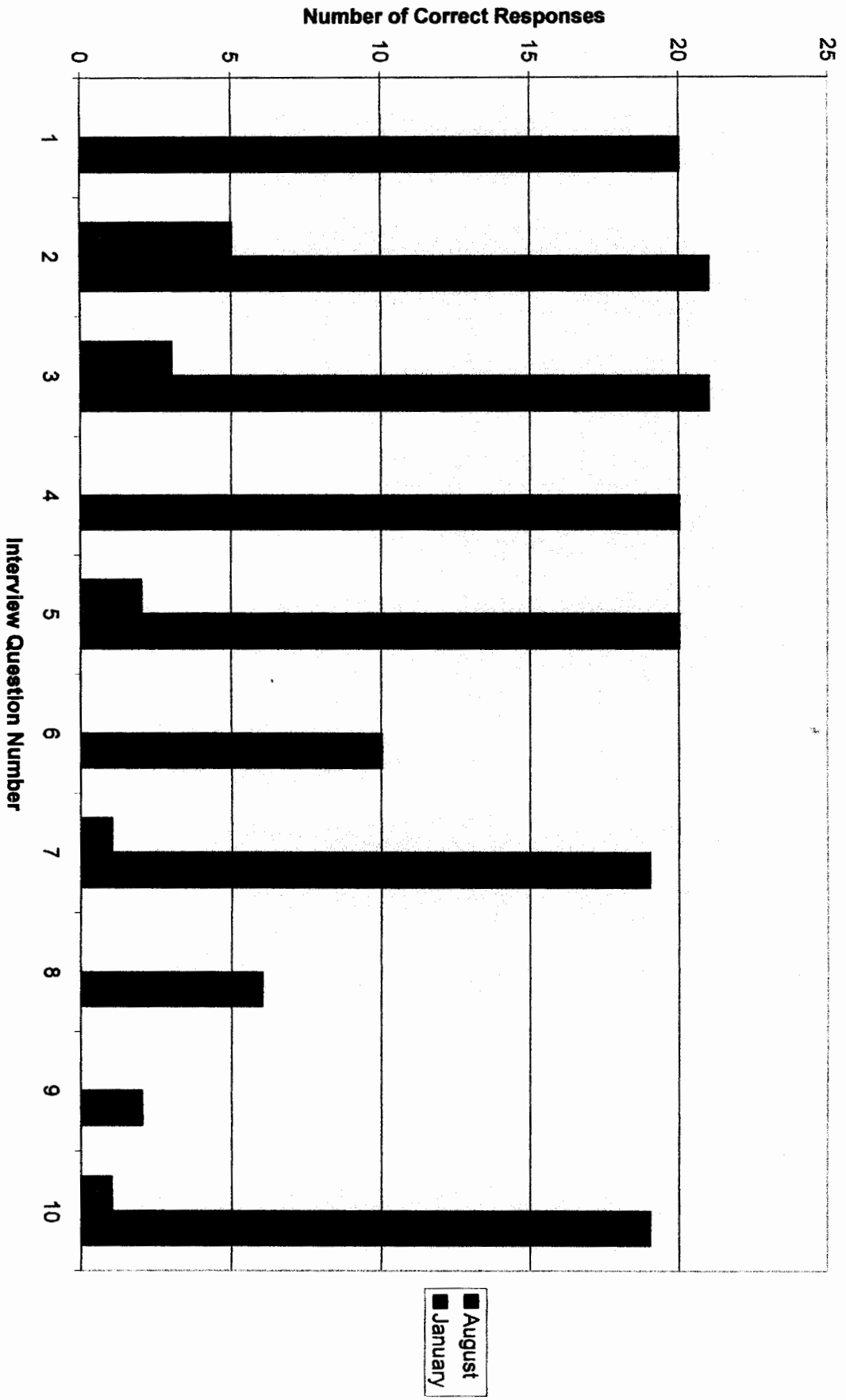
Appendix D


Student Interview - January Strategies
Student Responses
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
Interview Question Number
Count All
Count On
Count Back
Known Fact
Used 10
Other

Appendix D


student interview-January representations
student responses
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
interview question number
fingers
counters
picture
mental
other

Appendix E


Student Interview
Number of Correct Responses
0
5
10
15
20
25
Interview Question Number
1
2
3
4
5
6
7
8
9
10
August
January

A21-1

Name _____ Date_____ /21

1	2	2	1	4	4	3
+5	+2	+1	+3	+2	+1	+3
3	5	1	1	2	3	4
+2	+1	+2	+4	+3	+1	+2
3	1	2	5	1	1	2
+3	+1	+4	+1	+4	+5	+3

A21-1

Name _____ Date_____ /21

1	2	2	1	4	4	3
+5	+2	+1	+3	+2	+1	+3
3	5	1	1	2	3	4
+2	+1	+2	+4	+3	+1	+2
3	1	2	5	1	1	2
+3	+1	+4	+1	+4	+5	+3

A45-1

Name _____ Date_____ /45

2	1	2	1	2	6	6	5	2
+8	+6	+3	+3	+4	+2	+3	+1	+7

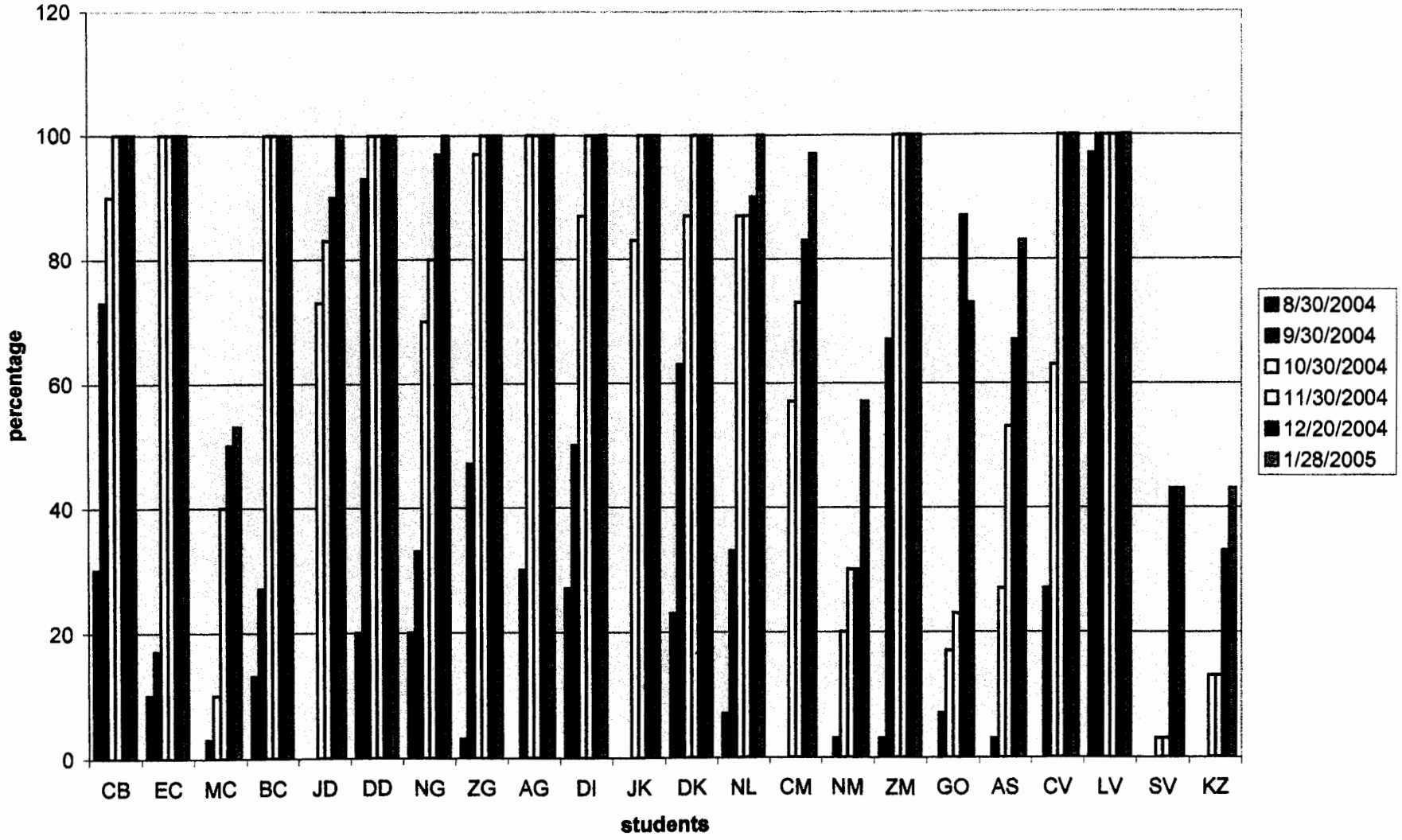
3	8	4	5	3	2	1	1	5
+7	+1	+3	+5	+4	+6	+4	+9	+3

4	2	8	1	7	1	3	3	6
+6	+1	+2	+2	+2	+5	+2	+6	+4

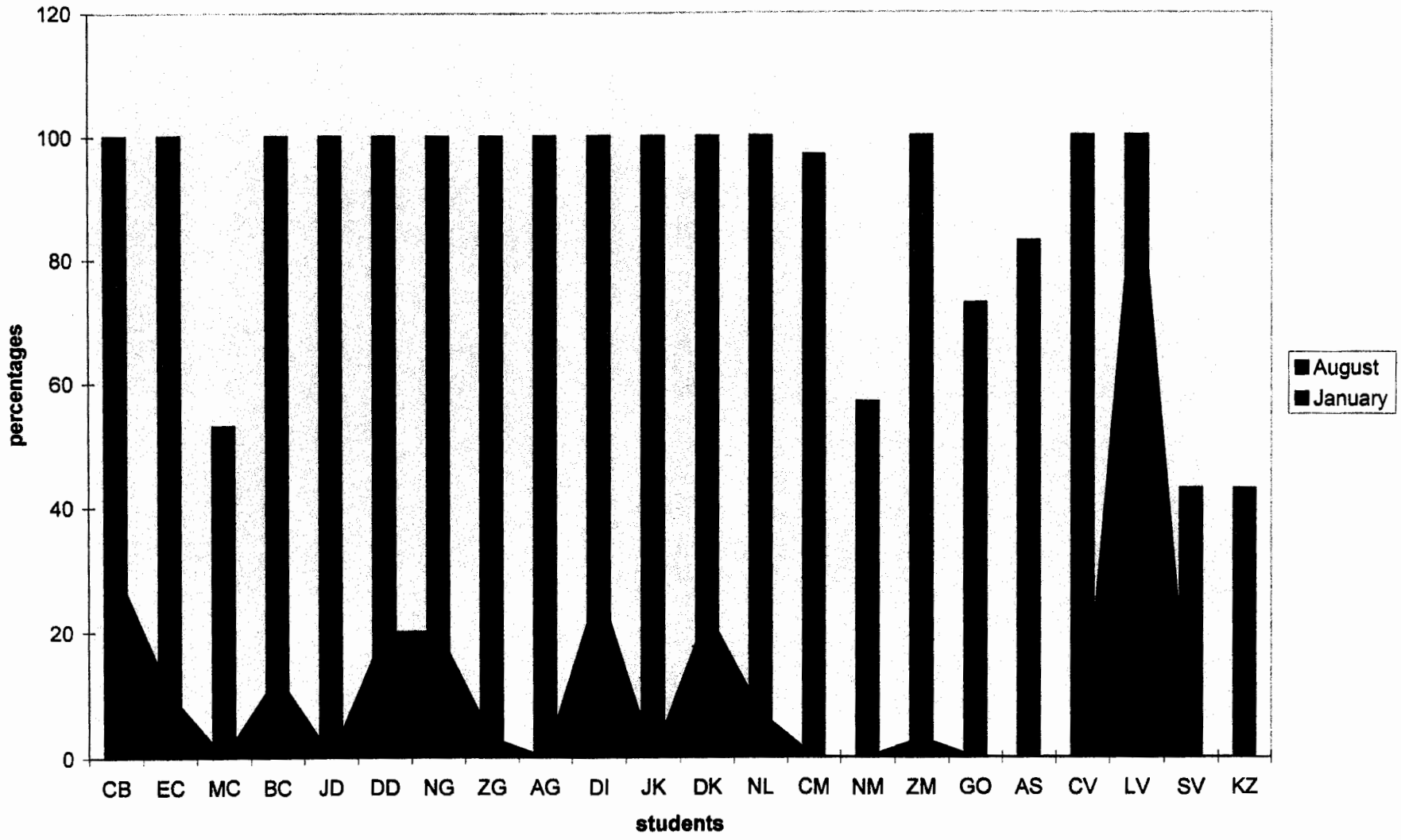
6	1	2	4	3	2	7	1	3
+1	+7	+5	+4	+5	+2	+3	+1	+ 3

4	5	4	4	5	1	9	3	7
+1	+4	+ 2	+5	+2	+8	+1	+1	+1

Appendix H


three-minute timed test on basic addition facts by percentages
120
100
80
60
40
20
0
percentage
CB
EC
MC
BC
JD
DD
NG
ZG
AG
DI
JK
DK
NL
CM
NM
ZM
GO
AS
CV
LV
SV
KZ
students
8/30/2004
9/30/2004
10/30/2004
11/30/2004
12/20/2004
1/28/2005

Appendix I


Pre/Post three minute timed test on basic addition facts by percentages
120
100
80
60
40
20
0
percentages
CB
EC
MC
BC
JD
DD
NG
ZG
AG
DI
JK
DK
NL
CM
NM
ZM
GO
AS
CV
LV
SV
KZ
students
August
January

Following are the eight interview questions:

1. What did you base your math instructional curriculum on from October 2003 to April 2004?

2. What specific strategies did you use in teaching fourth grade math last year?

3. Were you given enough support through materials, resources and training while teaching fourth grade math last year? Why or why not?

4. Did the outcomes of the strategies meet your expectations? Why or why not?

5. What were your math goals for improving math scores?

6. When planning math lessons, did you collaborate with other fourth grade math teachers?

7. What strategies will you continue to use in your current teaching?

8. What future strategies will you implement or change?

Findings

Based on interviews, the responses are as follows:

Question one: **What did you base your math instructional curriculum on from October 2003 to April 2004?** All three teachers used the same math series. During team planning, they discussed the order in which to teach the chapters. They also based instruction using the scores from spring 2003 ITBS.

Question two: **What specific strategies did you use in teaching fourth grade math last year?** All three teachers interviewed used basic fact practice, manipulative, flash cards, and math games when teaching math. Teacher one worked with small groups on daily assignments while other students did independent work. She also had regular communication with parents on students' progress or lack of. Teacher one, along with a former fourth grade teacher, not included in this interview had created ITBS review quizzes based on item analysis from the previous year. She adds the review quizzes were only used prior to Fall ITBS, but not Spring ITBS. Teacher one wonders if the ITBS scores would have increased from fall 2003 to spring 2004 with continued use of the review quizzes throughout the year?

Question three: **Were you given enough support through materials, resources, and training while teaching fourth grade math last year? Why or why not?** Teacher one feels she was given enough support through materials and training, but thought it would have been nice to have volunteers and/or mentors available during math time. Teachers two and three feel they were not given enough support through training, materials, or resources. Both of these teachers were new to the building and were unaware of the availability of all the math materials until about mid year. Teachers two and three agreed that the series was old and materials were scattered everywhere when they started.

Question four: **Did the outcome of the strategies meet your expectations? Why or why not?** Teacher one believed the outcome of strategies met her expectations because many students made great progress throughout the school year, even though Spring ITBS was lower than Fall ITBS scores. Teacher two believed the outcome of the strategies met her expectations most of the time because most of her students seemed to improve when learning new concepts as the year progressed, even though ITBS scores

decreased from fall to spring. Teacher three says the outcome of the strategies did not meet her expectations because ITBS showed a decline rather than an increase, even though the fourth graders were "proficient" in all three areas.

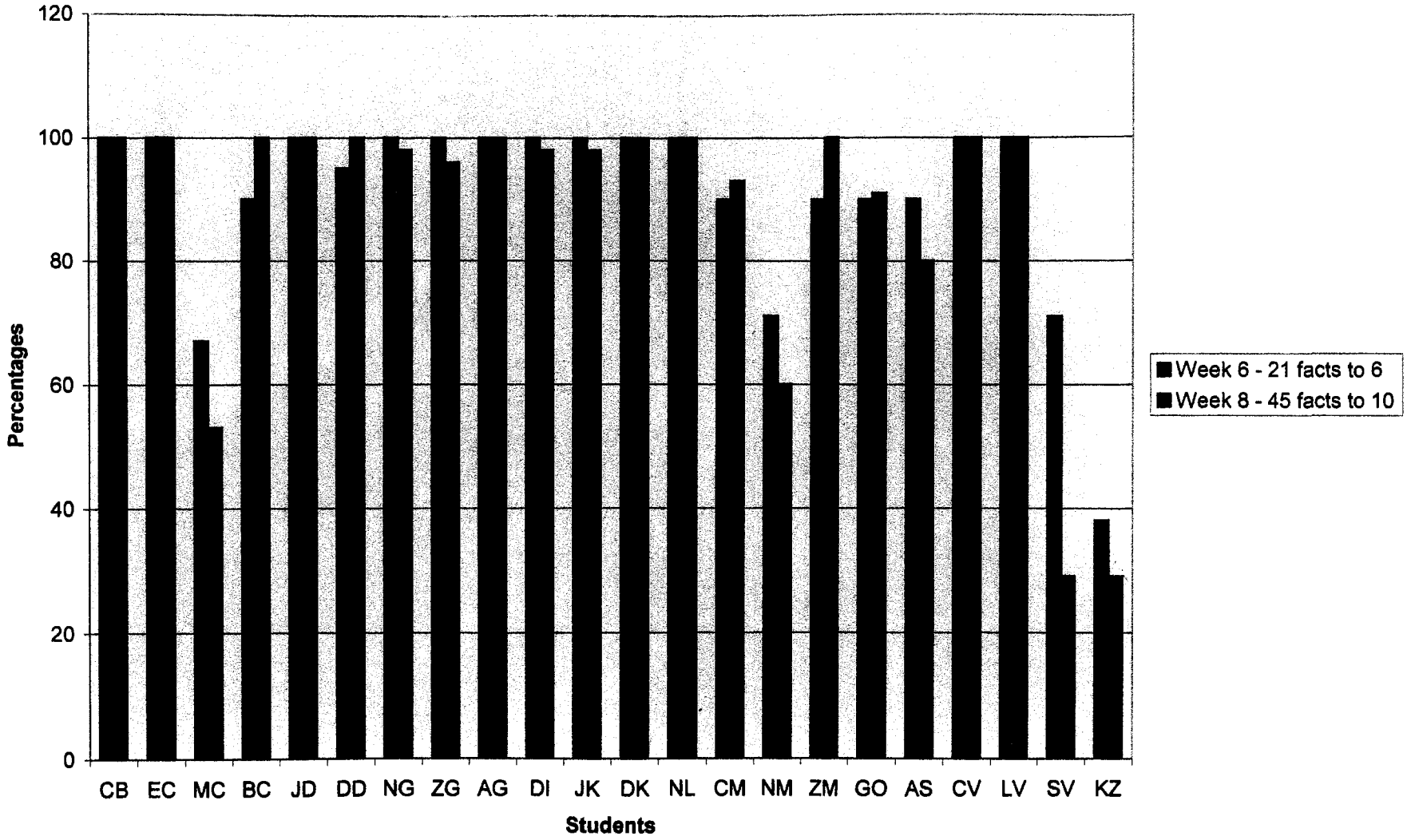
Question five: **What were your math goals for improving math scores?** All three teachers agreed the main goal was to improve basic facts. Teacher one also wanted students to be able to read a problem, come up with a plan, and then solve it on their own. She adds that this was very tough for them to do. Teacher two says by laying down the foundation of basic facts, students would find new and different concepts a little easier. She believes learning the basic facts did help her students. Teacher three says along with basic facts, her goal was to do more pre/post testing to align instruction. Another goal of hers was to send homework home on a regular basis.

Question six: **When planning math lessons, did you collaborate with other fourth grade math teachers?** Teacher one said yes, they collaborated when deciding the order in which to teach the chapters. Each teacher then focused on a chapter and suggested a time line for teaching and implementing the lessons. She adds more collaboration time is always needed. Teacher two and three said they occasionally got together for math collaboration, but again time was a factor. Teacher three responds by saying so many of the early out Wednesdays are taken by district needs and planning time is taken by student needs.

Question seven: **What strategies will you continue to use in your current teaching?** Teacher one will continue with basic facts and helping students become problem solvers. Teacher two will continue to work on basic facts everyday and do more partner work. Teacher three will continue to increase practice and application on identified skill needs.

Question eight: **What future strategies will you implement or change?** Teacher one feels she needs to look at the new curriculum and implement the strategies suggested in the new math series. She also plans to do more review with the students. Teacher two plans to get started on the new computer program that is included with the new math series. She says she excited about implementing technology into her math lessons. Teacher three plans to have her students do more writing in their math journals. She also plans to focus on identified skills as identified on the item analysis of ITBS.

Appendix K


District Addition Timed Test - Quarter 2
120
100
80
60
40
20
0
Percentages
CB EC MC BC JD DD NG ZG AG DI JK DK NL CM NM ZM GO AS CV LV SV KZ
Students
Week 6 - 21 facts to 6
Week 8 - 45 facts to 10