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I am submitting herewith a dissertation written by Joshua David Booher entitled "Do Increased Opportunities To Respond Enhance Generalization From Multiplication To Division." I have examined the final paper copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Christopher Skinner, Major Professor

We have read this dissertation
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# DO INCREASED OPPORTUNITIES TO RESPOND ENHANCE GENERALIZATION FROM MULTIPLICATION TO DIVISION

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Joshua David Booher
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# Dedication

This dissertation is dedicated to my wife, Andrea, without whose support it would not have been possible.

## Acknowledgements

I wish to thank those who helped me in completing my Ph.D. in Education with a concentration in School Psychology. I wish to thank my committee chair, Dr. Christopher Skinner, for his guidance and support during the last three years. I also wish to thank the rest of my committee, Dr. Sherry Bain, Dr. Charles Thompson, and Dr. Vey Nordquist for their efforts and support.

I also wish to thank my parents for their support and encouragement as I pursued my education.

# Abstract

Haring and Eaton (1978) proposed four levels of skill development; acquisition, fluency, generalization, and adaptation. Many researchers and educators have focused on improving skill acquisition and fluency. This study was designed to investigate whether increasing a student's opportunities to respond (practice) would increase generalization of learning from multiplication to division.

The participants were 31 students from two third-grade magnet classes in an inner-city school. The research design was a within-participants repeated measures ANOVA. Three levels of the independent variable, practice, were investigated (high, low, no). Outcomes were measured at three different times (Days 1, 8, and 10). Multiplication and division performance were the dependent variables. There were four measures of the dependent variables; number attempted, number correct, percent correct, and digits correct per minute.

Three mutually exclusive sets of multiplication problems were generated for this study. Each set consisted of 10 one-digit by one-digit multiplication problems. These problems were used to generate three types of sheets (intervention sheets, multiplication assessment sheets, and division assessment sheets). The difference between the intervention and assessment sheets was that the intervention sheets had the answers with the problems.

The study was conducted over a 10-day period. On the first day, the students were given the pretest. On the second day, they were taught how to perform the Cover, Copy, and Compare technique. On the third through seventh days, the students performed the

Cover, Copy, and Compare intervention. On the eighth day, the students were given their first posttest. On the ninth day, the students were taught how to generalize their learning from multiplication to division. On the tenth day, the students were administered the second posttest.

No significant interaction effects (interaction between time and practice) were found. In addition, the practice level did not increase the level of generalization. The results showed time increased the level of generalization. Time was a significant factor in fourteen of twenty-four comparisons across the three days (Day 1 to Day 8, Day 8 to Day 10, and Day 1 to Day 10). These results failed to support the hypothesis that increasing students' practice would enhance generalization. The discussion focuses on methodological problems of the current study and threats to the internal validity. Testing effects, spillover effects, history effects, and poor treatment integrity may have contaminated results.

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# Chapter 1

## *Introduction*

### *Definition of Terms*

Relevant definitions of select terms are presented below for better understanding by the reader:

*Skill Development:* The ability to perform a new skill in response to progressively more complex settings (Haring & Eaton, 1978).

*Acquisition:* The period between the first appearance of the desired behavior and the reasonably accurate performance of that behavior (Haring & Eaton, 1978).

*Fluency:* The ability to accurately respond at a high rate of speed (Haring & Eaton, 1978).

*Automaticity:* The ability to perform a skill using less cognitive processing capacity (Hasselbring, Goin, & Bransford, 1987).

*Maintenance:* The ability to retain a skill over time (Haring & Eaton, 1978).

*Generalization:* The performance of a skill in response to new stimuli similar to those used during instruction (Haring & Eaton, 1978).

*Adaptation:* The ability to modify or adapt performance of a skill in response to new problems or in new situations (Haring & Eaton, 1978).

*Opportunities to Respond:* The number of times a student is given the opportunity to actively respond to an academic task (practice) (Gettinger, 1995).

*Cover, Copy, Compare:* A self-managed intervention shown effective for increasing academic performance across curriculum areas, student populations, and settings (McLaughlin & Skinner, 1996).

*Basic Addition and Multiplication Facts:* The whole number single-digit addition and multiplication problems (e.g. $2 + 3 = 5$, $2 \times 8 = 16$) (Garnett & Fleischner, 1983).

*Basic Subtraction and Division Facts:* The inverse of the basic addition and multiplication facts (Garnett & Fleischner, 1983).

*Overcorrection:* When an error occurs, the correct response is practiced (Azrin & Powers, 1975).

*Overlearning:* The practice and reinforcement of skills beyond the point of initial mastery (Vockel & Mihail, 1993).

To master a skill, one must pass through four levels of skill development (Haring & Eaton, 1978). The first level is acquisition. Acquisition is the period between the first appearance of the desired behavior and the reasonably accurate performance of that behavior.

Fluency building, or proficiency, is the second level of skill development (Haring & Eaton, 1978). In the fluency building level, the learner is capable of responding correctly to a task, but has not yet attained the degree of fluency necessary to meaningfully use the skill.

The third level of skill development, generalization, requires the individual to perform a skill in response to a new stimulus, which is similar to those used during instruction (Haring & Eaton, 1978). This is not a passive phenomenon. Generalization must be planned for and instructed using discrimination and differentiation training.

Application or adaptation is the highest level of skill development (Haring & Eaton, 1978). At this level, the individual can modify the skill in response to new problems or new situations.

In order to progress through these stages of skill development, students must engage in active academic responding (Ebbinghaus, 1885/1964; Ivarie, 1986; Krueger, 1929). Additionally, if these responses are to enhance skill development they must be accurate. One procedure that has been shown to enhance opportunities to respond, accuracy, and fluency (i.e., speed of accurate responding) is Cover, Copy, and Compare (CCC).

*Cover, Copy, and Compare Technique*

CCC has five steps (McLaughlin & Skinner, 1996). The student studies the problem and its solution. The student covers the problem and solution, writes the problem and solution next to the covered problem, uncovers the target problem and solution, and evaluates the response. If it was written correctly, the student moves to the next problem. If not, the student repeats the process.

CCC is a simple procedure that takes little time for students to learn. Since each trial takes a brief amount of time, the student may complete many trials in a short period of time (Skinner, McLaughlin, & Logan, 1997). CCC also yields high rates of accurate responding, immediate feedback on response accuracy, and the last response the student makes is always correct. Thus, CCC is a self-paced learning strategy that may occasion high rates of accurate academic responding.

CCC has been shown to be effective for enhancing acquisition of skills (accuracy) and fluency (speed of accurate responding). However, researchers have not determined if the high rates of responding during CCC can enhance skill generalization. The primary purpose of the current study was to extend research on CCC and opportunities to respond by determining if increasing CCC multiplication fact learning trials enhances performance (accuracy and fluency) on division facts.

# Chapter 2

## *Review of the Literature*

In the National Assessment of Educational Progress's 1992 investigation (Mullis, 1994), 26,000 4th, 8th, and 12th grade students from 1,500 public and private schools were tested in mathematics. The average percentage correct, on short answer questions, was 42% for 4th-grade students, 53% for 8th-grade students, and 40% for 12th-grade students. On extended constructed-response questions, which the students had to demonstrate their reasoning and problem-solving abilities, one-third to two-thirds of the students provided incorrect answers, with up to 20% of the students leaving their papers blank. In addition, many of the students who appeared to understand the problems had difficulties explaining their work.

Throughout the elementary school years, a sizable portion of time allotted for arithmetic instruction is dedicated to training students for acquisition and fluency of the basic number facts (Fleischner, Garnett, & Shepherd, 1982). Basic number facts comprise all single-digit by single-digit addition and multiplication problems and their inverse subtraction and division problems (Garnett & Fleischner, 1983). When working with the basic number facts, speed and accuracy in answering problems are important because the basic number facts are prerequisite for future mathematics skills. Therefore, the goal is to have students master these basic facts.

### *The Learning Hierarchy*

There are several levels of skill development that lead to mastery. Haring and Eaton (1978) outline four levels of skill development and instructional-learning procedures designed to enhance performance at each level. The first level is acquisition, which is the period between the first appearance of the desired behavior and reasonably accurate performance of that behavior. When working with students in this stage, the emphasis should be on enhancing accuracy. Strategies for enhancing acquisition include demonstrations, models, cues, and routine drills.

The second level of skill development is fluency building or proficiency (Haring & Eaton, 1978). In this stage, the learner is capable of correctly responding to a task, but the learner has not yet attained the degree of fluency necessary to use the skill in a meaningful way. Fluency is also referred to as automaticity (Hasselbring, Goin, & Bransford, 1987). During fluency building, the goal is to enhance the speed of accurate responding. Repeated novel drills and reinforcement are strategies used to enhance fluency.

Generalization, the third level of skill development, requires performing a skill in response to new stimuli similar to those used during instruction (Haring & Eaton, 1978). During this stage, emphasis should be placed on having students respond to novel stimuli. Discrimination and differentiation training are two effective strategies that help students learn to identify situations in which the skill is applicable and situations in which it is not applicable.

There are four categories of generalization. These include, generalization across time, settings, modalities, and tasks. Generalization over time is often referred to as maintenance. For skills to be functional, they must be maintained over time. For example, a student learns a task today and needs to remember it next week for the test. Students also need to be able to generalize learning across settings. For example, facts students learn in mathematics class need to be able to be applied in science class. A third category of generalization is across modalities. A student who learns to write multiplication facts should also be able to perform basic operations cognitively. The final category of generalization is across tasks. Facts learned for one task (multiplication) need to be able to be applied to appropriate and related tasks (division).

The final level of skill development is application or adaption (Haring & Eaton, 1978). This represents the highest level of skill development in Haring and Eaton's (1978) learning hierarchy. In application, the skill can be modified in response to new problems or in new situations. Problem solving and simulations are useful strategies for enhancing adaptation.

*Overlearning and Effects*

The basic principal behind overlearning is that skills are practiced beyond the point of cognition (Vockell & Mihail, 1993). Overlearning enhances fluency and maintenance (Haring & Eaton, 1978). Ebbinghaus (1885/1964) ran a series of studies in which he read six series of 16 nonsense syllables 8, 16, 24, 32, 42, 53, or 64 times. Ebbinghaus knew from previous studies that it took him an average of 31 repetitions to learn a list to the first errorless reproduction. Twenty-four hours later, he sat down and relearned the lists to the first errorless reproduction. He found that he saved an average of 12.7 seconds the second day for each repetition of the list the first day. Ebbinghaus used the term "savings" to denote that he maintained some of the acquired knowledge over time. Currently, the term maintenance is used to denote this same phenomenon.

Krueger (1929) also performed an experiment in which he investigated the effects of different percentages of overlearning trials on retention. He measured the number of trials necessary to reach initial mastery of different lists of words and then continued the learning trials for 50%, 100%, or 200% more trials. He then assessed verbal recall of the word lists after 1, 2, 4, 7, 14, and 28 days for different groups. Krueger found that 50% overlearning is economical for retention, or maintenance, with intervals of 2 to 28 days. The larger the interval the greater the economy.

In the learning process, fluency and maintenance also were shown to be related concepts by Ivarie (1986). Ivarie ran a study with 120 4th-grade students. Based on prior achievement, these students were classified as average, above average, and below average. Over three consecutive days, the students were taught Roman and corresponding Arabic numerals. Within each group of students, half of the students were taught the information until they reached 70 responses per minute with 10% or fewer errors. The other half of the students were taught the information until they reached 35 responses per minute with 10% or fewer errors. Posttests were given immediately and after one, two, and three months. Students in the higher mastery level group performed better than those in the lower mastery level group, after three months. However, there was a significant interaction effect, with the below average and average groups showing the most interaction, with the higher mastery group displaying significantly better maintenance than the lower mastery group. This study showed that higher levels of fluency may result in more information being retained (maintenance).

*Time Needed to Learn*

Students do not obtain skills at equivalent rates. Gettinger (1995) refers to this rate as "time needed to learn" (TTL). TTL is composed of three parts; time allocated for learning, time needed by the student for learning, and time engaged in learning, which is referred to as academic engaged time. Academic engaged time is also composed of three parts; allocated times, engaged time, and success time. The time students need to reach criterion during initial instruction may predict retention and application or transfer of learned materials.

*Cover, Copy, and Compare – An Overlearning Procedure*

Cover, Copy, and Compare (CCC) is an easy technique to learn and apply (McLaughlin & Skinner, 1996). The only materials that are needed are a pencil/pen and a sheet of paper with the problems written down the left-hand side. The student studies the first problem and its solution, covers the problem and solution (Cover), writes the problem and solution to the right of the covered problem and solution (Copy), uncovers the target problem and solution, and evaluates the response (Compare). If the target problem was written correctly, the student moves to the next problem. If the target problem was written incorrectly, the student repeats the problem.

Cover, Copy, and Compare is beneficial for several reasons. First, it is easy to train students to use CCC (McLaughlin & Skinner, 1996). Second, due to the brief time required for a trial, students are able to complete many learning trials in a brief amount of time. Third, error rates are low, and the accuracy of their work is immediately evaluated. Thus, students are reinforced immediately for correct responses. Finally, if a response is incorrect, the student repeats it and therefore the last trial is always performed correctly (Skinner, McLaughlin, & Logan, 1997).

A technique, such as CCC, can make a difference with respect to both engaged time and success time. First, since virtually the entire time a student is working with CCC the student is responding, the engagement rate is high. Signs of high engagement time are paying attention, completing written problems, and interacting with peers about assigned work (Gettinger, 1995). When using CCC, students do not interact with peers. However, the other two indices, paying attention and completing written work, are crucial to the written form of CCC. Success rate is also very high in all forms of CCC procedures.

Several studies have investigated the effectiveness of the CCC technique and the Add-A-Word technique, which is used for learning spelling words, on skill development (Struthers, Bartalamay, Bell, & McLaughlin, 1994; Skinner, Bamberg, Smith, & Powell, 1993; Skinner, Belfiore, & Pierce, 1992; Skinner, Turco, Rasavage, & Beatty, 1989). The CCC technique has been used primarily as an acquisition level technique, since it is used to assist students in learning basic facts.

The Cover, Copy, and Compare technique has been used to improve students' fluency with basic multiplication facts. For example, Skinner, Turco, Rasavage, and Beatty (1989) used a within-subjects multiple baseline design to evaluate the effectiveness of the CCC technique on 4 behaviorally disordered students' multiplication rates. Skinner, Turco, et al., created three mutually exclusive sets of 10 single-digit by single-digit multiplication problems. Each day of the intervention, the students were assessed first and then performed the CCC intervention. All three of the students that completed the study showed improvement in their ability to accurately perform multiplication facts. In addition, two of the three students showed improvements when maintenance data was collected. This study showed that students' fluency can be improved by implementation of the CCC procedures.

The Cover, Copy, and Compare technique has been shown to enhance performance across modalities (i.e., generalization). Skinner, Bamberg, Smith, and Powell (1993) studied 3 male students who were from a classroom in a private school for behavioral disorders. The study used a within-subjects, across-problems multiple baseline design. In the traditional written-CCC (W-CCC) problems are written down and then compared for accuracy. The advantage to this technique is that a permanent product is created. A second form of CCC is cognitive-CCC (C-CCC), in which students subvocally say (copy) the problem and then compare what they said to the answer. The advantage to this form is that students can practice more items in a given length of time. In this study, Skinner, Bamberg, et al., used the C-CCC technique to improve the students' ability to accurately perform division problems.

For three or four days a week, the teacher had the students practice six division fact sheets using C-CCC at their desks. The teacher allowed 6 minutes for the task, but it never took the full allotment of time. The next morning the facts were assessed. When a set of facts was mastered (40 digits correct with no errors on three of four consecutive assessments), six sheets from a new set of unmastered problems were given to the student. Only one student was not able to master a set of problems in nine sessions. This student was told of his time across all three sets of problems and told of the mastery criteria. This provided additional feedback and a goal. The students increased their rates of accurate responding (i.g. fluency) after using the C-CCC technique. The students were assessed with a paper-and-pencil test of the division facts. This shows that facts learned using C-CCC techniques generalize to other modalities (subvocal to written).

Skinner, Belfiore, and Pierce (1992) performed a study in which 7 elementary school students with social emotional disturbances used CCC to help them learn state locations. The study used a multiple baseline across items design to determine whether CCC was effective in improving the students' accuracy in identifying states on a map of the United States. For the intervention, the 50 states were divided into five sets of geographically related states moving from the East coast to the West coast. Then, each set was practiced using the CCC procedure on a map with all 50 states labeled on it stapled to the outside of a manila file folder and an identical map without the states labeled placed inside of the manila file folder. First, the students shuffled the set of states. Second, they found the first state on the map. Third, they opened the folder to the blank map and placed a penny on the state. Last, they closed the map and compared the answer. If the penny was on the correct state, they would move on to the next state. If the penny was on the wrong state, they repeated the procedure until they got the state correct. In just over six CCC sessions per set of states, the children were able to correctly identify 80% or higher of the states in a set. In addition, the students not only maintained their performance at the one month follow up, they actually improved their performance in labeling states. This shows that facts learned using the CCC technique are maintained (generalized over time).

The Add-A-Word technique (AAW) for spelling has been shown to be effective in promoting Haring and Eaton's (1978) generalization level (Struthers, Bartalamay, Bell, & McLaughlin, 1994). The AAW technique uses the same intervention as the CCC technique. However, when using the AAW technique, mastered words are moved off of the list and new words are added. Mastered words are brought back onto the list later to ensure that they are being maintained.

Struthers, Bartalamay, Bell, and McLaughlin (1994) increased the spelling accuracy in creative writing of 12 mildly handicapped students by using the AAW technique to improve the spelling accuracy of selected words on regular spelling lists. A multiple baseline across four spelling lists and two classrooms was used in the study. In the study, the students' creative writing journals were observed for words that were misspelled consistently. These words were added to the student's regular spelling word lists and the AAW technique was used to increase the spelling fluency of these words. Then, the spelling accuracy of these words was viewed in the student's creative writing journal. The results showed generalization across settings and tasks of the accurate spelling of words from the Add-A-Word setting to the accurate spelling of the same words in creative writing journals.

*Overcorrection*

The principal behind overcorrection states that when an error occurs, the individual practices the correct behavior (Azrin & Powers, 1975). Carey and Bucher (1986) believe that overcorrection can be a beneficial component of skill-building programs because it requires the practice of skills correctly after an error occurs. Azrin and Powers (1975) studied 6 boys ages 7 to 11-years old, who had been referred to a summer school program for being extremely disruptive in the classroom. Four techniques ([1] Warnings, Reminders, and Reinforcement, [2] Loss of Recess, [3] Delayed Overcorrection, [4] Immediate Overcorrection) were used in an ABCD design to compare their relative effectiveness in reducing the disruptive behaviors. The two overcorrection techniques reduced the disruptions immediately by 95% and 98% respectively. The 3% difference between the two forms of overcorrection was not significant. Azrin and Powers (1975) suggest that overcorrection procedures may be effectively utilized in large general education classrooms or in smaller Special Education classrooms.

*Summary and Purpose*

Haring and Eaton (1978) suggest that mastered skills should be able to generalize from one task to another. However, this has never been demonstrated between multiplication and division. Therefore, this study will attempt to demonstrate this phenomenon.

The purpose of the current study is to determine if increasing opportunities to respond enhances generalization from multiplication to division. Three sets of multiplication problems were developed. One set was practiced using CCC for 2 minutes each day (high practice level) the other was practiced for 30 seconds each day (low practice level) and the third set was not practiced (no practice level). Assessment data was collected on multiplication and division performance for each set of problems to determine if opportunities to respond to multiplication facts influenced division fact accuracy and fluency.

# Chapter 3

## *Methodology*

### *Subjects and Setting*

The participants were students from an inner-city school in a southeastern U.S. school district. The school serves approximately 730 kindergarten through 5th-grade students from its own district and a technology magnet program that draws students from across the county. All students were enrolled in a 3rd-grade magnet classroom for mathematics instruction. The participants were selected because they were from magnet classrooms and the school administration believed that the experimenter would get a higher response rate for the permission slips if the magnet students were targeted.

After gaining permission from the central office, the school principals, classroom teachers, and the University of Tennessee Institutional Review Board (IRB), permission slips were sent home to parents to complete and sign granting permission for their child to participate in the study. (See Appendix A for the parental consent form.)

Across two 3rd-grade magnet classrooms, 37 of 38 students returned completed and signed parental consent forms. Of these 37 students, one child's parents declined to let their child participate in the study. Five other students missed one or more assessment days, and their data was dropped from the study. Thus, data from 31 participants from the two 3rd-grade magnet classrooms were analyzed.

As Figure 1 shows, 55% of the participants were African-American (17 of 31 participants). It is not known what race the other 14 participants were, because the magnet program tracks students on two classifications only, African-American and Non-African-American. There were 16 male and 15 female participants.

Count

| | | GENDER | | Total |
|---|---|---|---|---|
| | | Male | Female | |
| RACE | African-American | 7 | 10 | 17 |
| | Non-African-American | 9 | 5 | 14 |
| Total | | 16 | 15 | 31 |

Figure 1. Race Classification and Gender Classification Totals

*Materials*

Appendix B displays the three mutually exclusive sets of multiplication facts that were generated for use in this study. Each set of multiplication facts (Set A, Set B, and Set C) consisted of 10 multiplication problems. Each problem consisted of a one-digit factor multiplied by a one-digit factor. No problems with factors of one or zero were included in any of the sets. No problems were repeated within the same set or another set of problems. Sets were constructed so that the number of times the digits 2 through 9 were used did not differ by more than one across sets, except for the digit 4, which appeared in Set A twice, Set B once, and Set C four times. In addition, the sum of the products of each set totals 313.

The three sets of problems were used to create three types of sheets (intervention sheets, multiplication assessment sheets, and division assessment sheets). The multiplication assessment sheets were created by randomly drawing the ten problems from a problem set and listing the problems without the answers horizontally down the left hand side of a standard 8 1/2 inches by 11 inches sheet of white paper. On the upper right hand corner of the sheet spaces were provided for the date, the length of time in seconds each sheet was allotted, the number of problems the participant attempted, the number of problems the participant got correct, the percentage of attempted problems the participant got correct, and the number of digits correct per minute. The problem set letter (A, B, or C) was then placed in the center of the top of the page.

This was done six different times to make six variations of the multiplication assessment sheet for each problem set. In addition, each time a problem was used on the second, fourth, and sixth variation, the order of the factors was counterbalanced with the order of the factors on the previously completed sheet. For instance, if "2 x 5 =" was used on the first multiplication sheet, when that problem was selected for the second sheet, it would be presented as "5 x 2 =". This would mean that each problem was presented in both forms three times.

This same procedure was used to create the division assessment sheets. However, for the division assessment sheets, the divisor was balanced across sheets. If "40 ÷ 8 =" was presented on the first sheet, for the next sheet "40 ÷ 5 =" was presented. The multiplication intervention sheets were constructed in the same manner as the assessment sheets. The only difference was that the answers were printed following each problem.

Once the different assessment and intervention sheets were created, they were combined into assessment and intervention packets. For each problem set (A, B, and C), multiplication and division assessment packets were constructed by stapling 12 sheets together (two copies of the six variations). Each student's identification number was written on the top right-hand side of the stapled packets. Assessment sheet sequence was counterbalanced across students. Each of the six stapled packets were placed in a manila envelope with the student's identification number written on the outside of the envelope.

For the intervention packets, 12 sheets (two copies of the six variations) were stapled together and the student's number was placed on the stapled packet for both the high and low intervention level. Then, an orange dot was placed on the packet the student would be completing first that day. Once this was done, the packets the student would be working with were placed in a manila folder with the student's number on the outside.

To eliminate increases in performance caused by procedural training, a similar intervention sheet was constructed using addition problems. These problems were not based upon any of the sets of multiplication problems. Twelve of these sheets were stapled together for the students to use during the training session. Also, a stopwatch and pencils were used during the experiment.

*Experimental Design*

This experiment utilized a within-participants repeated measures ANOVA design. It included three levels of the independent variable (high, low, no) that were assessed at three different times (Figure 2).

The independent variable was allotted time for practice. To alter the allotted time, the Cover, Copy, and Compare technique was used at three levels across the three problem lists. At the high level, the participants practiced a list for 2 minutes per day. At the low level, participants practiced a different list for 30 seconds per day. At the no level, no intervention was performed on the list.

Previous researchers found that 2 students, ages 10 and 11 years old, were able to complete 7.65 and 8.64 problems per minute respectively during a time constant written Cover, Copy, Compare technique (Skinner, Belfiore, Mace, Williams-Wilson, & Johns, 1997). These rates average approximately eight problems completed per minute. With

| | Pretest | Posttest 1 | Posttest 2 |
|---|---|---|---|
| High | | | |
| Low | | | |
| No | | | |

Figure 2. Repeated Measures ANOVA Design

comparable rates, the participants in this study should be able to complete approximately 16 problems during the 2 minute high practice level and approximately four problems during the 30 second low practice level. Over a five-day intervention, this would mean practicing 80 high level problems and 20 low level problems. This would mean working through the high level problem set approximately eight times and the low level set approximately twice.

Problem sets were counterbalanced across intervention levels, with approximately one third of the participants being assigned a specific set of problems at a given level (Figure 3). The set (i.g. high or low) participants practiced first during the intervention, was alternated across days.

Each of the 31 participants performed the CCC technique on one set of problems for the high level, a second set of problems for the low level, and the last set of problems for the none level each intervention day. Since there were to be no learning trials for the none intervention level, the participants did not perform the CCC intervention on the set of problems for the none level, even though they were assigned a set of problems for the

| | Set A | Set B | Set C |
|---|---|---|---|
| High | 11 | 8 | 12 |
| Low | 8 | 12 | 11 |
| No | 12 | 11 | 8 |

Figure 3. Counterbalance of Sets Across Intervention Levels

none level. However, the none level problem set was assessed on the three assessment days.

*Procedures*

*General.* The experimenter conducted all sessions in the participants' magnet classrooms at approximately the same time every day. In the first classroom, it was approximately 9:30-10:00 a.m. each day. In the second classroom, it was approximately 10:00-10:30 a.m. each day. The participants completed the sessions at their desks at the beginning of mathematics class. Sessions were conducted each weekday for 2 weeks (See Appendix C for the sequence of events).

*Pretest.* On the first day, six different assessment packets were given to the participants in a manila envelope. Each of the multiplication lists and the corresponding division lists were assessed. Before each pretest began, the experimenter read the participants the following instructions:

> Please, pull out the packet with the _____ star on it. On each of the sheets are 10 multiplication or division problems. You will be given 1 minute to complete the problems. Complete them as quickly as you can, but try to get them all correct.

Do not skip any of the problems. When you finish, turn the sheets face down and place your pencil on your desk. Ready, begin.

The experimenter then used the stopwatch to time 1 minute. The methods for scoring the sheets are described in the section *Dependent Variables.*

*Cover, copy, and compare training.* On the second day, the experimenter taught the participants the five-step CCC procedure. The experimenter demonstrated and explained how to (A) study the first problem and its solution, (B) cover the problem and solution with their hand, (C) write the problem and solution to the right of the covered problem and solution, (D) uncover the target problem and solution, and (E) evaluate the response. If the target problem was written incorrectly, the participants were told to copy the target problem correctly three times and then repeat the steps. If the target problem was written correctly, the participants were told to continue on to the next problem.

The experimenter demonstrated three trials using a chalkboard. In the first two trials the target problems were copied correctly. In the third trial, the target problem was first copied incorrectly and then correctly. The experimenter verbalized all of the steps during the demonstrations and answered the students' questions after the entire CCC process had been demonstrated. Questions were answered and the process was repeated until the participants reported they understood the entire process. The participants then practiced the technique using the addition sheets, while the experimenter walked around the room observing. When necessary, the experimenter stopped the participant, explained the step that was performed incorrectly, and demonstrated a correctly performed trial. During the demonstration and student practice, addition problems and answers were used.

*Cover, copy, and compare interventions.* During the third through seventh days, the participants were given their intervention packets and told on which packet (the one with the orange dot) to begin the CCC procedure. The experimenter walked around the classroom and observed the students. If the students were observed performing the CCC procedure incorrectly, the experimenter stopped the student and described and demonstrated the step in which the error was made. [Some students required corrections every day of the study.] During each session, the students completed the CCC procedure for the high practice level sheets for two minutes and the low practice level worksheets for thirty seconds. The order of the treatment (high and low) was counterbalanced across days.

*Posttest 1.* On Day 8, each of the multiplication lists and the corresponding division lists were assessed. The assessment packets were given to the students at the beginning of the session in a manila envelop with their number on the outside. Before each posttest began, the experimenter read the participants the following instructions:

> Please, pull out the packet with the _____ star on it. On each of the sheets are 10 multiplication or division problems. You will be given 1 minute to complete the problems. Complete them as quickly as you can, but try to get them all correct. Do not skip any of the problems. When you finish, turn the sheets face down and place your pencil on your desk. Ready, begin.

The experimenter then used the stopwatch to time 1 minute. The sheets were scored in the same manner as the pretest sheets (see *Dependent Variables*).

*Train to generalize.* On the ninth day, a short lecture was presented to the students in which the relationship between multiplication and division was explained. The definitions of multiplication and division used in the presentation were taken from Math (Charles, et al., 1999), the book used for mathematics instruction in the classroom. A chalkboard was used to demonstrate the fact family triangles and their relationship to multiplication and division (Appendix D). The participants were shown that going two ways around the triangle is multiplication and that reversing either direction is division.

*Posttest 2.* Each of the multiplication and corresponding division lists were assessed on Day 10. The assessment packets were given to the students at the beginning of the session in a manila envelope with their number on the outside. Before each posttest began, the experimenter read the participants the following instructions:

> Please, pull out the packet with the _____ star on it. On each of the sheets are 10 multiplication or division problems. You will be given 1 minute to complete the problems. Complete them as quickly as you can, but try to get them all correct. Do not skip any of the problems. When you finish, turn the sheets face down and place your pencil on your desk. Ready, begin.

The experimenter then used the stopwatch to time 1 minute. The sheets were scored in the same manner as the pretest sheets (see *Dependent Variables*).

*Dependent Variables*

In this study, there are two dependent variables. The first dependent variable, multiplication performance, is the direct dependent variable. The second dependent variable, division performance, is the generalized dependent variable. Each of the dependent variables was measured in four ways. First, the total number of problems attempted on each set of assessment sheets was measured. This was a measure of speed. Second, the total number of problems the student got correct on each set of assessment sheets was measured. Third, the percentage of problems attempted that were correct on each set of assessment sheets was measured (percent correct = number correct / number attempted). Partially completed problems were not scored as attempted. This is a measurement of accuracy. Last, the number of correct digits per minute on each assessment measured fluency (Shapiro, 1996).

The number of correct digits per minute was calculated in the following manner. A number was scored correct if the correct digit appeared in the correct answer place. For example, the multiplication problem "9 x 7 = XX" could be scored 0, 1, or 2 digits correct. If the answer given was 63, it was scored 2 digits correct, since both the tens and ones digit were correct. If the answer given was 67, it was scored as 1 digit correct, because the tens digit was correct and the ones digit was incorrect. If the answer provided was 33, it was scored 1 digit correct, because the tens digit was incorrect and the ones digit was correct. If the answer provided was 36, it was scored a 0, because neither place (tens or ones) contained an accurate digit. After each digit was scored, the number of correct digits was totaled, yielding digits correct per minute.

Division problems were scored the same way. For example, the problem "56 ÷ 8 = X" could be scored either 0 or 1 digit correct. If the answer given was 7, it was scored as 1 digit correct, because the digit was correct and placed in the correct answer space. If the answer provided was 8, it was scored a 0, because the digit in the answer space was incorrect. After each digit was scored, the number of correct digits was totaled. The number is then divided by the number of minutes the participant was assessed, which was 1 minute.

*Data Analysis Procedures*

A series of repeated measures ANOVAs were used to test for significant differences on each dependent variable (multiplication and division performance) using each of the four ways of measuring the dependent variables (number attempted, number correct, percent correct, digits correct per minute). The within-subject factor was time (pretest, posttest 1, and posttest 2). The between-subject factor was level of practice (high, low, no). Differences were considered significant at the $p \leq .05$ level.

*Treatment Integrity*

A second experimenter observed the primary experimenter implementing the steps. If the step was performed correctly, it was marked on a check sheet (Appendix E). If the step was not performed correctly, the step was not marked.

Integrity was calculated by dividing the number of steps planned and done (those items marked on the check sheet) by the number of planned steps done plus the number of planned steps not done (the total number of items on the appropriate section of the check sheet). Overall, 98% (262 of 266) of the steps were correctly completed. The four steps that were not completed as intended were checks to see whether the students had a working pencil. Three of these checks were missed on the first day.

There was one error that was not identified by the check sheet. On Day 6, the times were reversed for the intervention sheets. The worksheets that should have been practiced 2 minutes were practiced 30 seconds and the worksheets that should have been practiced 30 seconds were practiced 2 minutes.

*Interobserver Agreement*

A second experimenter assessed every fifth assessment sheet across the pretest and two posttests for a total of 126 assessments rescored (7 participants x 6 assessments x 3 days). No individual participant's sets of assessments were checked across multiple days. Therefore, 21 different participants had a set of assessments rescored. Interobserver agreement was calculated by dividing the number of agreements per assessment by the number of agreements per assessment plus disagreements per assessment and multiplying by 100. There was 100% agreement for 123 of the 126 assessments. On the other three assessments, the interobserver agreement was 86%, 89%, and 97%.

# Chapter 4

## *Results*

All analyses were computed using the SPSS 11.0.1 software. The repeated measures analysis of variance test was used to assess the four measures (digits correct per minute, percent correct, number correct, and number attempted) across the two dependent variables (multiplication and division performance). The analysis was conducted with the two independent variables time and practice, which created three possible effects: time effects, practice effects, and time by practice effects.

The results for the main effect practice and the interaction effects will be presented for each measure. Within each section, multiplication results will be discussed, followed by division. Finally, the results of the main effect time will be discussed for all four measures across the dependent variables.

### *Digits Correct Per Minute*

For multiplication problems, digits correct per minute was not significant for practice [$F(2, 29) = 1.327$, $p = .281$] (Table 1) or time by practice interactions [$F(4, 27) = .264$, $p = .899$] (Table 1). For division problems, digits correct per minute was not significant for practice [$F(2, 29) = .826$, $p = .448$] (Table 2) or time by practice interactions [$F(4, 27) = .191$, $p = .941$] (Table 2).

As Figures 4 and 5 show, there is consistent improvement of both multiplication and division digits correct per minute across time. By Day 10, for both multiplication and division, the high practice level is higher than the low practice level. However, the no practice levels improved at a similar rate to the high and low practice levels.

Table 1. Repeated Measures Analysis of Multiplication Digits Correct Per Minute

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .084 | 1.327[a] | 2.000 | 29.000 | .281 |
| | Wilks' Lambda | .916 | 1.327[a] | 2.000 | 29.000 | .281 |
| | Hotelling's Trace | .092 | 1.327[a] | 2.000 | 29.000 | .281 |
| | Roy's Largest Roc | .092 | 1.327[a] | 2.000 | 29.000 | .281 |
| TIME | Pillai's Trace | .366 | 8.363[a] | 2.000 | 29.000 | .001 |
| | Wilks' Lambda | .634 | 8.363[a] | 2.000 | 29.000 | .001 |
| | Hotelling's Trace | .577 | 8.363[a] | 2.000 | 29.000 | .001 |
| | Roy's Largest Roc | .577 | 8.363[a] | 2.000 | 29.000 | .001 |
| TIME * PRACTIC | Pillai's Trace | .038 | .264[a] | 4.000 | 27.000 | .899 |
| | Wilks' Lambda | .962 | .264[a] | 4.000 | 27.000 | .899 |
| | Hotelling's Trace | .039 | .264[a] | 4.000 | 27.000 | .899 |
| | Roy's Largest Roc | .039 | .264[a] | 4.000 | 27.000 | .899 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

Table 2. Repeated Measures Analysis of Division Digits Correct Per Minute

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .054 | .826[a] | 2.000 | 29.000 | .448 |
| | Wilks' Lambda | .946 | .826[a] | 2.000 | 29.000 | .448 |
| | Hotelling's Trace | .057 | .826[a] | 2.000 | 29.000 | .448 |
| | Roy's Largest Roc | .057 | .826[a] | 2.000 | 29.000 | .448 |
| TIME | Pillai's Trace | .454 | 12.041[a] | 2.000 | 29.000 | .000 |
| | Wilks' Lambda | .546 | 12.041[a] | 2.000 | 29.000 | .000 |
| | Hotelling's Trace | .830 | 12.041[a] | 2.000 | 29.000 | .000 |
| | Roy's Largest Roc | .830 | 12.041[a] | 2.000 | 29.000 | .000 |
| TIME * PRACTIC | Pillai's Trace | .028 | .191[a] | 4.000 | 27.000 | .941 |
| | Wilks' Lambda | .972 | .191[a] | 4.000 | 27.000 | .941 |
| | Hotelling's Trace | .028 | .191[a] | 4.000 | 27.000 | .941 |
| | Roy's Largest Roc | .028 | .191[a] | 4.000 | 27.000 | .941 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

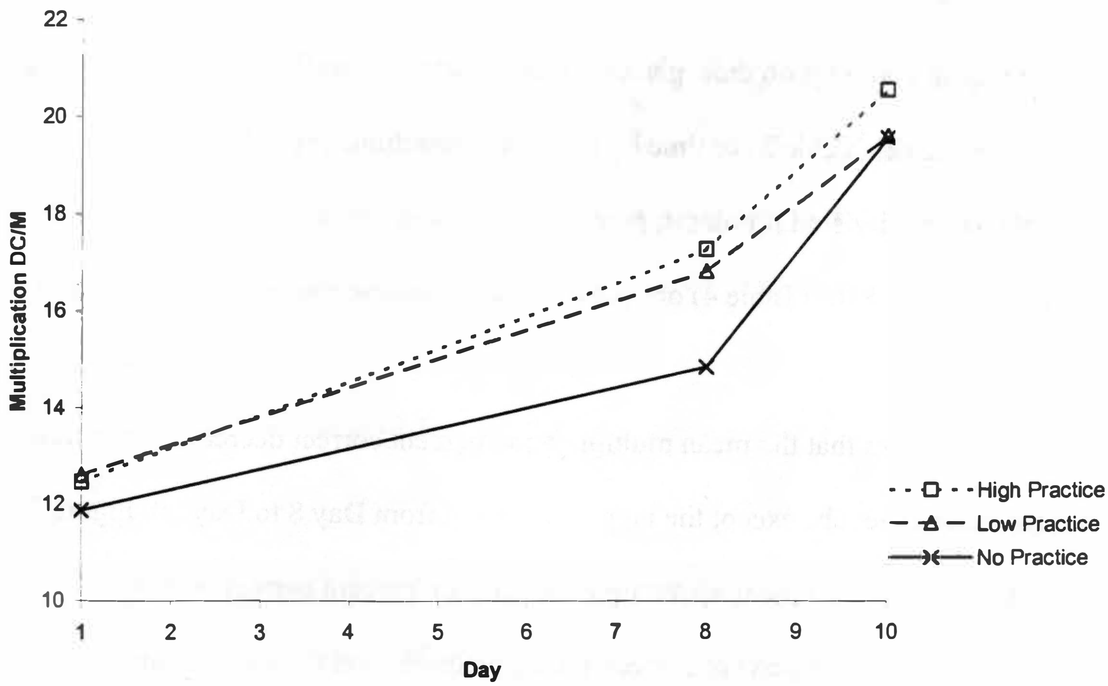


Figure 4. Multiplication Digits Correct Per Minute Means Across Time

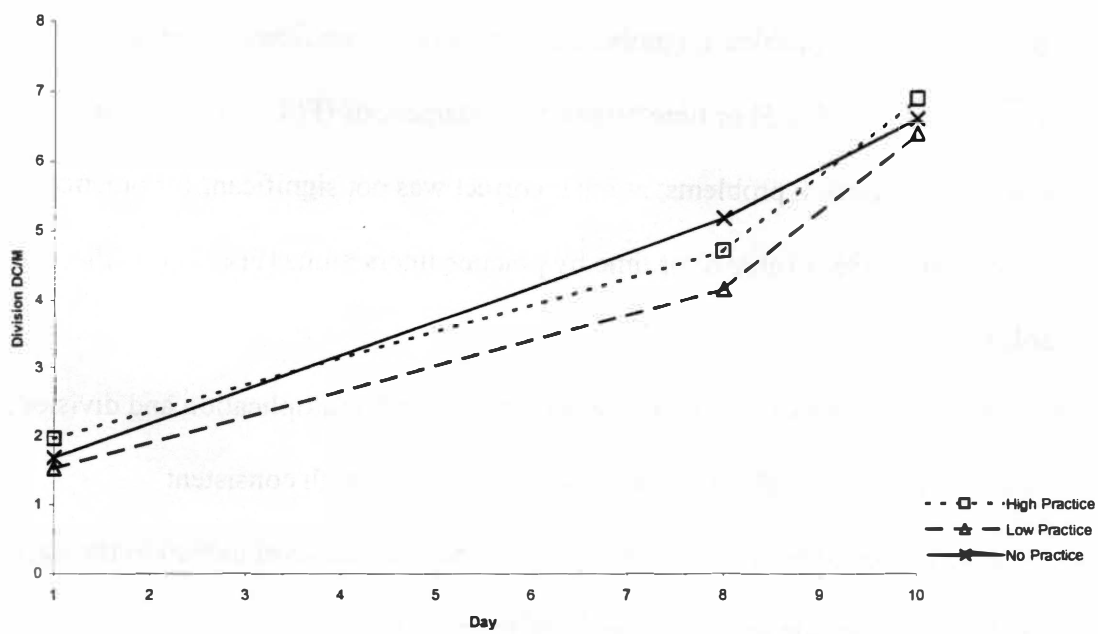


Figure 5. Division Digits Correct Per Minute Means Across Time

*Percent Correct*

For multiplication problems, percent correct was not significant for practice [F(2, 29) = 1.360, $p$ = .272] (Table 3) or time by practice interactions [F(4, 27) = 2.262, $p$ = .089] (Table 3). For division problems, percent correct was not significant for practice [F(2, 29) = .181, $p$ = .836] (Table 4) or time by practice interactions [F(4, 27) = .115, $p$ = .976] (Table 4).

Figure 6 shows that the mean multiplication percent correct decreased over time for all three practice levels, except the no practice level from Day 8 to Day 10. Figure 7 shows a consistent improvement across time for division percent correct. For both multiplication and division percent correct, the no practice level moved in a similar direction and rate as the high and low practice levels.

*Number Correct*

For multiplication problems, number correct was not significant for practice [F(2, 29) = 1.408, $p$ = .261] (Table 5) or time by practice interactions [F(4, 27) = .322, $p$ = .861] (Table 5). For division problems, number correct was not significant for practice [F(2, 29) = .459, $p$ = .636] (Table 6) or time by practice interactions [F(4, 27) = .204, $p$ = .934] (Table 6).

Figures 8 and 9 show that for Days 8 and 10, for both multiplication and division, the high practice level was higher than the low practice level, with consistent improvement across the time period. Once again, the no practice level moved in the same direction and at a similar rate to the high and low practice levels.

Table 3. Repeated Measures Analysis of Multiplication Percent Correct

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .086 | 1.360[a] | 2.000 | 29.000 | .272 |
| | Wilks' Lambda | .914 | 1.360[a] | 2.000 | 29.000 | .272 |
| | Hotelling's Trace | .094 | 1.360[a] | 2.000 | 29.000 | .272 |
| | Roy's Largest Roc | .094 | 1.360[a] | 2.000 | 29.000 | .272 |
| TIME | Pillai's Trace | .276 | 5.533[a] | 2.000 | 29.000 | .009 |
| | Wilks' Lambda | .724 | 5.533[a] | 2.000 | 29.000 | .009 |
| | Hotelling's Trace | .382 | 5.533[a] | 2.000 | 29.000 | .009 |
| | Roy's Largest Roc | .382 | 5.533[a] | 2.000 | 29.000 | .009 |
| TIME * PRACTIC | Pillai's Trace | .251 | 2.262[a] | 4.000 | 27.000 | .089 |
| | Wilks' Lambda | .749 | 2.262[a] | 4.000 | 27.000 | .089 |
| | Hotelling's Trace | .335 | 2.262[a] | 4.000 | 27.000 | .089 |
| | Roy's Largest Roc | .335 | 2.262[a] | 4.000 | 27.000 | .089 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

Table 4. Repeated Measures Analysis of Division Percent Correct

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .012 | .181[a] | 2.000 | 29.000 | .836 |
| | Wilks' Lambda | .988 | .181[a] | 2.000 | 29.000 | .836 |
| | Hotelling's Trace | .012 | .181[a] | 2.000 | 29.000 | .836 |
| | Roy's Largest Roc | .012 | .181[a] | 2.000 | 29.000 | .836 |
| TIME | Pillai's Trace | .460 | 12.363[a] | 2.000 | 29.000 | .000 |
| | Wilks' Lambda | .540 | 12.363[a] | 2.000 | 29.000 | .000 |
| | Hotelling's Trace | .853 | 12.363[a] | 2.000 | 29.000 | .000 |
| | Roy's Largest Roc | .853 | 12.363[a] | 2.000 | 29.000 | .000 |
| TIME * PRACTIC | Pillai's Trace | .017 | .115[a] | 4.000 | 27.000 | .976 |
| | Wilks' Lambda | .983 | .115[a] | 4.000 | 27.000 | .976 |
| | Hotelling's Trace | .017 | .115[a] | 4.000 | 27.000 | .976 |
| | Roy's Largest Roc | .017 | .115[a] | 4.000 | 27.000 | .976 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

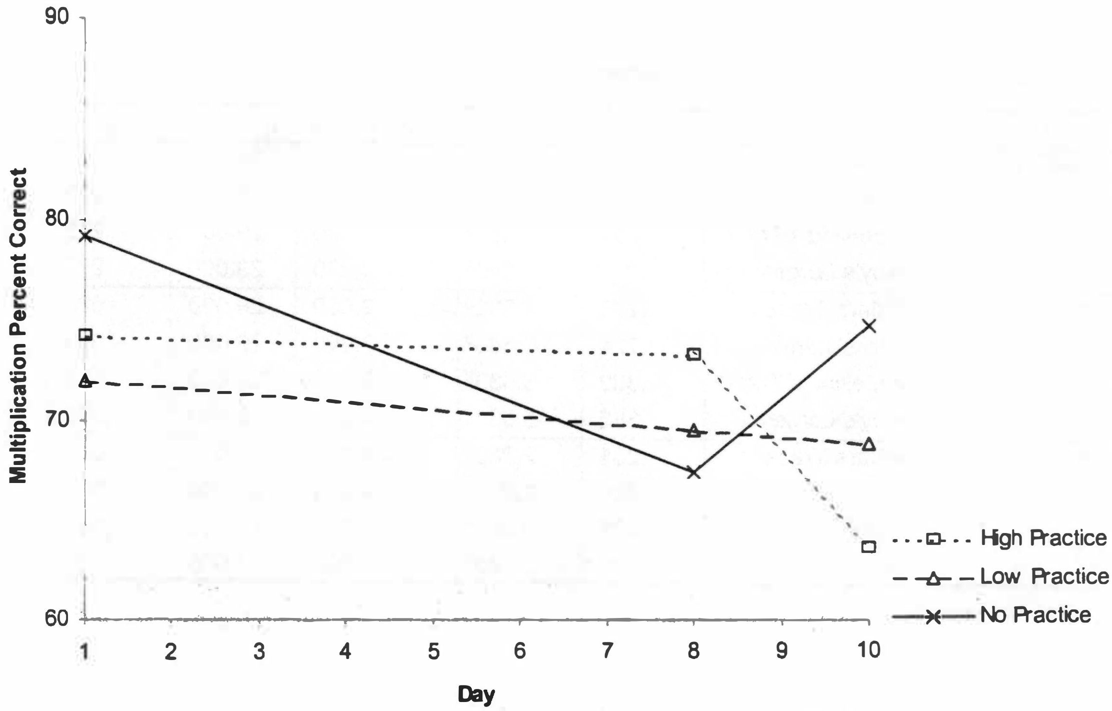


Figure 6. Multiplication Percent Correct Means Across Time

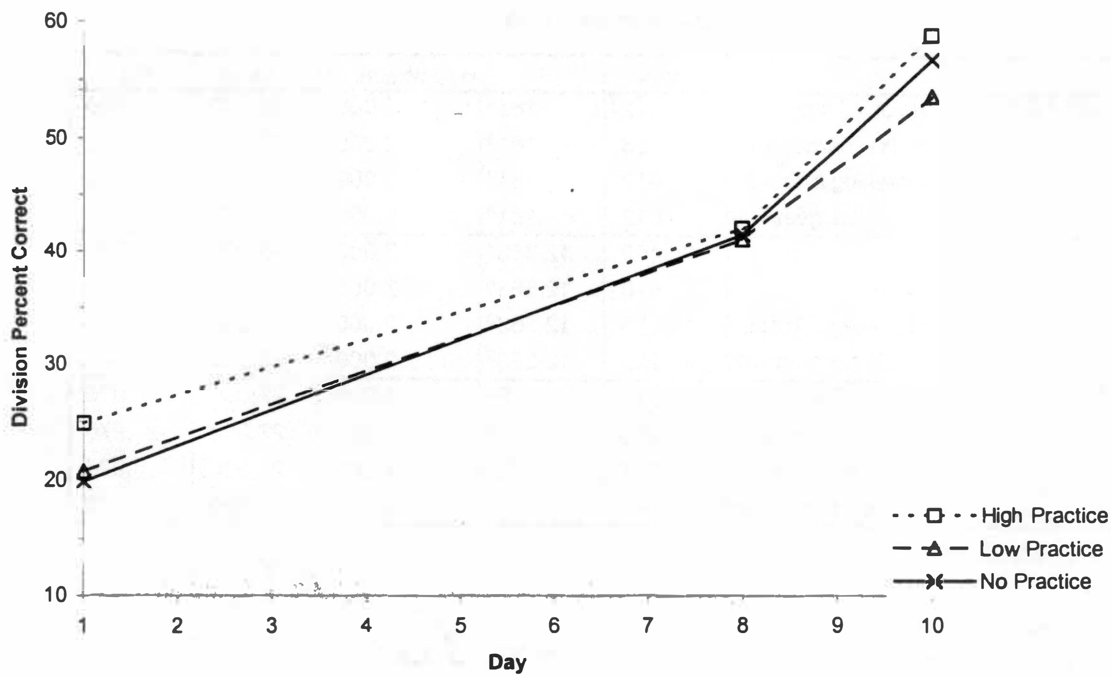


Figure 7. Division Percent Correct Means Across Time

Table 5. Repeated Measures Analysis Of Multiplication Number Correct

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .088 | 1.408[a] | 2.000 | 29.000 | .261 |
| | Wilks' Lambda | .912 | 1.408[a] | 2.000 | 29.000 | .261 |
| | Hotelling's Trace | .097 | 1.408[a] | 2.000 | 29.000 | .261 |
| | Roy's Largest Root | .097 | 1.408[a] | 2.000 | 29.000 | .261 |
| TIME | Pillai's Trace | .329 | 7.109[a] | 2.000 | 29.000 | .003 |
| | Wilks' Lambda | .671 | 7.109[a] | 2.000 | 29.000 | .003 |
| | Hotelling's Trace | .490 | 7.109[a] | 2.000 | 29.000 | .003 |
| | Roy's Largest Root | .490 | 7.109[a] | 2.000 | 29.000 | .003 |
| TIME * PRACTICE | Pillai's Trace | .046 | .322[a] | 4.000 | 27.000 | .861 |
| | Wilks' Lambda | .954 | .322[a] | 4.000 | 27.000 | .861 |
| | Hotelling's Trace | .048 | .322[a] | 4.000 | 27.000 | .861 |
| | Roy's Largest Root | .048 | .322[a] | 4.000 | 27.000 | .861 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

Table. 6. Repeated Measures Analysis Of Division Number Correct

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .031 | .459[a] | 2.000 | 29.000 | .636 |
| | Wilks' Lambda | .969 | .459[a] | 2.000 | 29.000 | .636 |
| | Hotelling's Trace | .032 | .459[a] | 2.000 | 29.000 | .636 |
| | Roy's Largest Roo | .032 | .459[a] | 2.000 | 29.000 | .636 |
| TIME | Pillai's Trace | .438 | 11.301[a] | 2.000 | 29.000 | .000 |
| | Wilks' Lambda | .562 | 11.301[a] | 2.000 | 29.000 | .000 |
| | Hotelling's Trace | .779 | 11.301[a] | 2.000 | 29.000 | .000 |
| | Roy's Largest Roo | .779 | 11.301[a] | 2.000 | 29.000 | .000 |
| TIME * PRACTIC | Pillai's Trace | .029 | .204[a] | 4.000 | 27.000 | .934 |
| | Wilks' Lambda | .971 | .204[a] | 4.000 | 27.000 | .934 |
| | Hotelling's Trace | .030 | .204[a] | 4.000 | 27.000 | .934 |
| | Roy's Largest Roo | .030 | .204[a] | 4.000 | 27.000 | .934 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

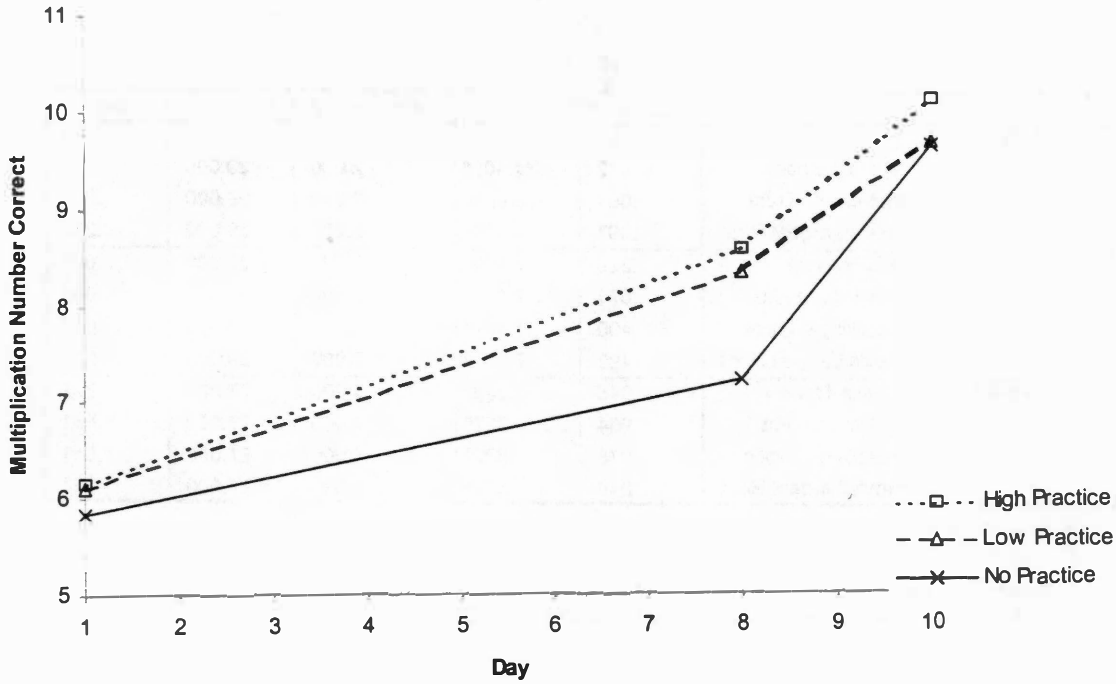


Figure 8. Multiplication Problems Correct Means Across Time

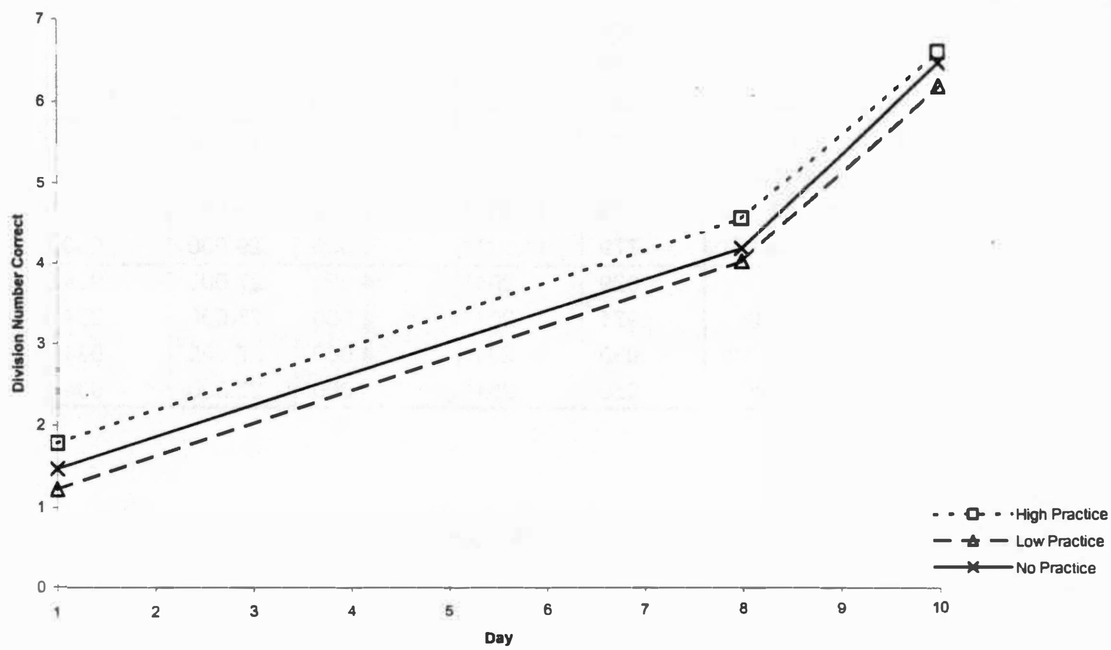


Figure 9. Division Problems Correct Means Across Time

*Number Attempted*

For multiplication problems, number attempted was not significant for practice [F(2, 29) = 2.504, $p$ = .099] (Table 7) or time by practice interactions [F(4, 27) = .992, $p$ = .429] (Table 7). For division problems, number attempted was not significant for practice [F(2, 29) = 1.066, $p$ = .357] (Table 8) or time by practice interactions [F(4, 27) = 1.040, $p$ = .405] (Table 8).

Figures 10 and 11 show consistent improvement across time for both multiplication and division problems attempted. On multiplication problems attempted, the no practice level was higher than the low practice level for Day 10.

*Time*

For multiplication problems, time was significant for digits correct per minute [F(2, 29) = 8.363, $p$ = .001] (Table 1), percent correct [F(2, 29) = 5.533, $p$ = .009] (Table 3), number correct [F(2, 29) = 7.109, $p$ = .003] (Table 5), and number attempted [F(2, 29) = 12.263, $p$ = .000] (Table 7). For division problems, time was significant for digits correct per minute [F(2, 29) = 12.041, $p$ = .000] (Table 2), percent correct [F(2, 29) = 12.363, $p$ = .000] (Table 4), number correct [F(2, 29) = 11.301, $p$ = .000] (Table 6), and number attempted [F(2, 29) = 4.685, $p$ = .017] (Table 8).

A comparison of the dependent variables was made across the three assessment days (Day 1 to Day 8, Day 8 to Day 10, Day 1 to Day 10). To protect against experimenterwise Type I error, the Bonferroni's correction was used (Anderson & Finn, 1996). To achieve an overall $\underline{p} < .05$, $\underline{p}$ has to be equal to or less than .002 (24 comparisons x $.002 \leq .05$). Table 9 shows results of the repeated measures analysis of variance analyses. Between Day 1 and Day 8, time was significant for all variables,

Table 7. Repeated Measures Analysis Of Multiplication Number Attempted

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .147 | 2.504[a] | 2.000 | 29.000 | .099 |
| | Wilks' Lambda | .853 | 2.504[a] | 2.000 | 29.000 | .099 |
| | Hotelling's Trace | .173 | 2.504[a] | 2.000 | 29.000 | .099 |
| | Roy's Largest Root | .173 | 2.504[a] | 2.000 | 29.000 | .099 |
| TIME | Pillai's Trace | .458 | 12.263[a] | 2.000 | 29.000 | .000 |
| | Wilks' Lambda | .542 | 12.263[a] | 2.000 | 29.000 | .000 |
| | Hotelling's Trace | .846 | 12.263[a] | 2.000 | 29.000 | .000 |
| | Roy's Largest Root | .846 | 12.263[a] | 2.000 | 29.000 | .000 |
| TIME * PRACTICE | Pillai's Trace | .128 | .992[a] | 4.000 | 27.000 | .429 |
| | Wilks' Lambda | .872 | .992[a] | 4.000 | 27.000 | .429 |
| | Hotelling's Trace | .147 | .992[a] | 4.000 | 27.000 | .429 |
| | Roy's Largest Root | .147 | .992[a] | 4.000 | 27.000 | .429 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

Table 8. Repeated Measures Analysis Of Division Number Attempted

**Multivariate Tests[b]**

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| PRACTICE | Pillai's Trace | .068 | 1.066[a] | 2.000 | 29.000 | .357 |
| | Wilks' Lambda | .932 | 1.066[a] | 2.000 | 29.000 | .357 |
| | Hotelling's Trace | .074 | 1.066[a] | 2.000 | 29.000 | .357 |
| | Roy's Largest Roo | .074 | 1.066[a] | 2.000 | 29.000 | .357 |
| TIME | Pillai's Trace | .244 | 4.685[a] | 2.000 | 29.000 | .017 |
| | Wilks' Lambda | .756 | 4.685[a] | 2.000 | 29.000 | .017 |
| | Hotelling's Trace | .323 | 4.685[a] | 2.000 | 29.000 | .017 |
| | Roy's Largest Roo | .323 | 4.685[a] | 2.000 | 29.000 | .017 |
| TIME * PRACTIC | Pillai's Trace | .134 | 1.040[a] | 4.000 | 27.000 | .405 |
| | Wilks' Lambda | .866 | 1.040[a] | 4.000 | 27.000 | .405 |
| | Hotelling's Trace | .154 | 1.040[a] | 4.000 | 27.000 | .405 |
| | Roy's Largest Roo | .154 | 1.040[a] | 4.000 | 27.000 | .405 |

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: PRACTICE+TIME+TIME*PRACTICE

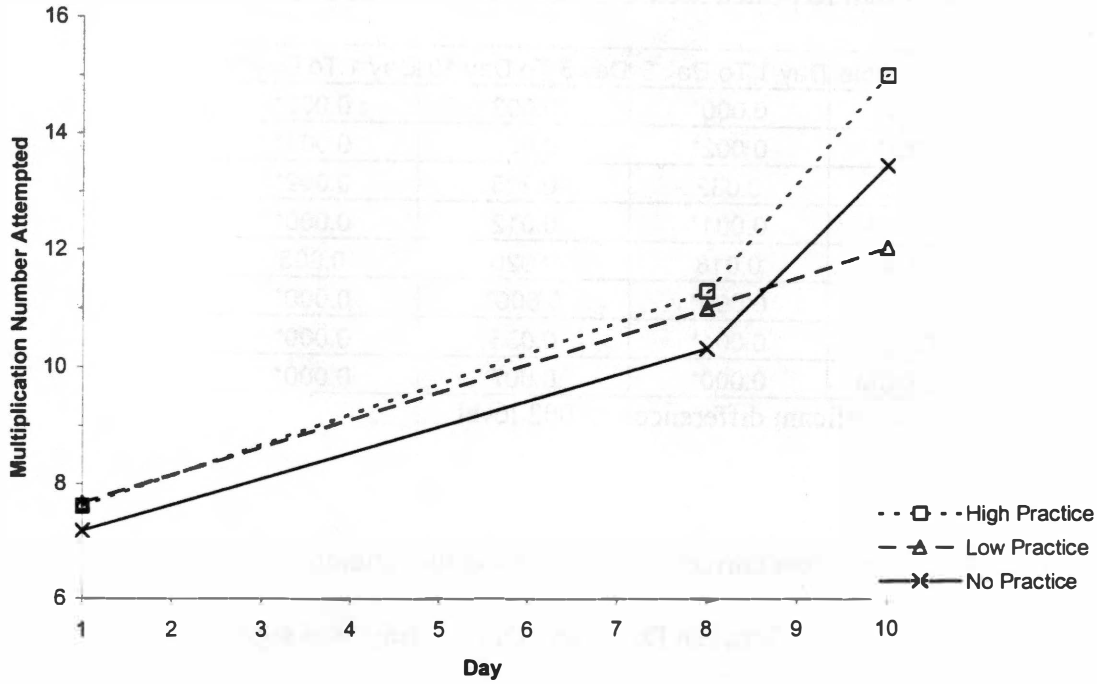


Figure 10. Multiplication Problems Attempted Means Across Time

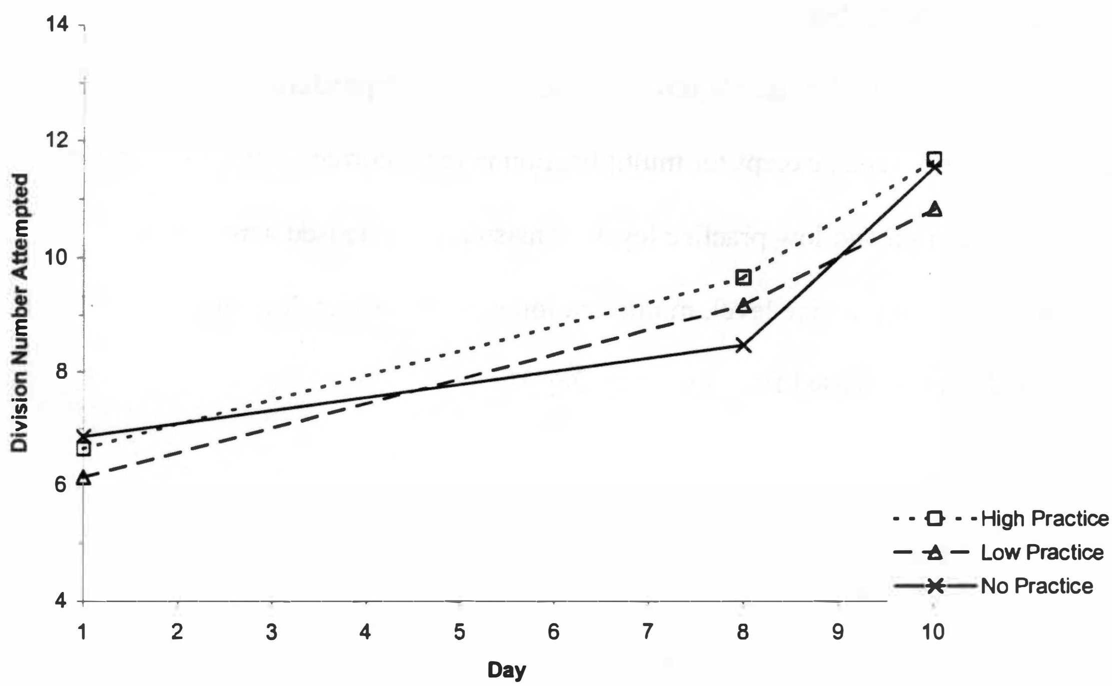


Figure 11. Division Problems Attempted Means Across Time

Table 9. P-Values From Repeated Measures ANOVAs Of The Time Factor

| Variable | Day 1 To Day 8 | Day 8 To Day 10 | Day 1 To Day 10 |
|---|---|---|---|
| MNA | 0.000* | 0.003 | 0.000* |
| MNC | 0.002* | 0.027 | 0.001* |
| MPC | 0.032 | 0.205 | 0.002* |
| MDCM | 0.001* | 0.012 | 0.000* |
| DNA | 0.018 | 0.020 | 0.005 |
| DNC | 0.000* | 0.000* | 0.000* |
| DPC | 0.001* | 0.033 | 0.000* |
| DDCM | 0.000* | 0.007 | 0.000* |

* significant differences at .002 level

except multiplication percent correct and division number attempted, with Day 8 performances being higher. Between Day 8 and Day 10, time was significant for division number correct, with Day 10 performance being higher. Between Day 1 and Day 10, time was significant for all variables, except division number attempted, with Day 10 performances being higher.

Table 10 shows that across time, the means for all dependent variables at all practice levels increased, except for multiplication percent correct. For multiplication percent correct, high and low practice levels consistently decreased across time. However, for the no practice level, multiplication percent correct decreased from Day 1 to Day 8 and then increased from Day 8 to Day 10.

Table 10. Dependent Variable Means Across Time

| | Multiplication | | | | | Division | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Number | Attempted | | | | Number | Attempted | |
| | Day 1 | Day 8 | Day 10 | | | Day 1 | Day 8 | Day 10 |
| High | 7.61 | 11.26 | 14.94 | | High | 6.64 | 9.66 | 11.67 |
| Low | 7.67 | 10.97 | 12.00 | | Low | 6.14 | 9.18 | 10.83 |
| None | 7.19 | 10.29 | 13.40 | | None | 6.86 | 8.47 | 11.54 |
| | | | | | | | | |
| | Number | Correct | | | | Number | Correct | |
| | Day 1 | Day 8 | Day 10 | | | Day 1 | Day 8 | Day 10 |
| High | 6.14 | 8.55 | 10.06 | | High | 1.78 | 4.50 | 6.53 |
| Low | 6.11 | 8.32 | 9.64 | | Low | 1.22 | 3.97 | 6.11 |
| None | 5.83 | 7.21 | 9.60 | | None | 1.47 | 4.13 | 6.40 |
| | | | | | | | | |
| | Percent | Correct | | | | Percent | Correct | |
| | Day 1 | Day 8 | Day 10 | | | Day 1 | Day 8 | Day 10 |
| High | 74.25 | 73.18 | 63.50 | | High | 24.86 | 41.89 | 58.58 |
| Low | 72.03 | 69.42 | 68.69 | | Low | 20.72 | 40.92 | 53.33 |
| None | 79.17 | 67.32 | 74.51 | | None | 19.86 | 41.32 | 56.46 |
| | | | | | | | | |
| | Digits | Correct | Per Minute | | | Digits | Correct | Per Minute |
| | Day 1 | Day 8 | Day 10 | | | Day 1 | Day 8 | Day 10 |
| High | 12.47 | 17.24 | 20.50 | | High | 1.97 | 4.71 | 6.89 |
| Low | 12.61 | 16.79 | 19.56 | | Low | 1.53 | 4.16 | 6.39 |
| None | 11.89 | 14.82 | 19.51 | | None | 1.69 | 5.18 | 6.60 |

# Chapter 5

## *Discussion*

### *Practice and Generalization*

This study was designed to determine if increasing opportunities to respond to multiplication facts enhanced multiplication fluency and division fluency. Analysis of interaction effects suggested that additional practice did not cause increases in either multiplication or division fluency. With respect to multiplication fluency, the current finding failed to support previous research which showed that increasing Cover, Copy, and Compare trials enhanced fluency (Skinner, Bamberg, Smith, & Powell, 1993; Skinner, Belfiore, & Pierce, 1992; Skinner, Turco, Rasavage, & Beatty, 1989). As different levels of practice did not have a significant influence on multiplication performance, it is not surprising to find no effect for the generalization task, division.

In the current study, time was the one variable that had a significant impact on performance. From Day 1 to Day 8, performance improved across all variables, except multiplication percent correct and division number attempted. From Day 8 to Day 10, performance improved only for the variable division number correct. From Day 1 to Day 10, performance improved for all variables, except number attempted.

Another purpose of the study was to determine if prompting students to generalize would enhance division performance. The results of this study show significant increases only in division number correct.

### *Limitations and Future Research*

Although the current study suggests that increasing opportunities to respond did not impact student performance, several limitations of the current study should be addressed before any strong conclusions are drawn. Specifically, future researchers should address threats to internal and external validity associated with the current study and methodological limitations of the current study.

*Threats to internal validity.* Testing effects occur when performance increases due to repeated assessments (Campbell & Stanley, 1963). In the current study, students' performances changed in a similar manner across dependent variables with each assessment. With respect to all measures except multiplication percent correct, testing effects may have caused increased performance. Specifically, each specific assessment session may have caused increases in performance. This testing effect may have been strongest between Days 8 and 10 as assessments closer together in time may be more susceptible to practice or testing effects. Future researchers conducting similar studies should attempt to reduce the influence of testing effects by increasing the length of time between assessments.

Within-subject designs are susceptible to multiple treatment interference (Anastas, 1999). In the current study, transfer of learning, sometimes called a spillover effect, from the high and low practice levels to the no practice level may have occurred. Sixty percent of all possible basic multiplication problems were used in the lists (30 of 50 problems). In addition, the problems considered easy were removed from the problem pool. Therefore, it is possible that enhancing high and low practice problems caused improvement on no practice problems. For example, a student who learned that "7 x 8 = 56" may then easily calculate "7 x 9 = 63". Future researchers could attempt to reduce multiple treatment interference by using between-subjects designs, a smaller pool of items included in all three sets, or unrelated items.

History effects may also have contaminated the current study. The third-grade students in this study had some previous exposure to multiplication facts. Additionally, they had just started working on division facts. Therefore, some of these students may have had materials at home designed to help them master these facts (e.g., learning games, flash cards) and may have used these materials to help them improve their performance during the study. Using younger students with no prior exposure to multiplication or division facts may help future researchers reduce the possible impact of history effects.

Treatment integrity may also have influenced the current results. In several instances students were observed performing the CCC procedure incorrectly. Specifically, they were observed writing problems and answers without covering them. Thus, they were merely copying problems and answers. Although when students were observed merely copying problems and answers, they were prompted to perform the procedure correctly, it is likely that many instances of copying went unnoticed. This could be corrected in future studies by having more research assistants present or having fewer students and monitoring the application of the intervention more carefully. Additionally, technological advances (e.g., using computers where the problem and answer drops from the screen before they can key in the problem and answer) could prevent this from occurring.

Finally, the process used to test students may have caused increases in performance that masked any effects of differential practice. Previous researchers have shown that explicitly timing students enhances their mathematics performance, especially their fluency (Rhymer, Henington, Skinner, & Looby, 1999; Rhymer, Skinner, Henington, D'Reaux, & SanPier, 1998). It is possible that the use of 1 minute assessment procedures, in and of themselves, caused increases in performance. Future researchers should consider using less reactive assessment procedure (e.g., covert timing) to control for these effects (e.g., see Evans-Hampton, Skinner, Henington, SanPeir, & McDaniel, 2002).

*Methodological limitations.* In the current study, there may not have been a large enough discrepancy between the time the participants were engaged in the high, low, and no practice levels of the intervention. It might be that longer than two minutes of practice on the high level was needed to gain a significant difference between the high and none practice levels. A corollary to this is that more than five days might be needed for the intervention. It may be possible that the no practice level would plateau after a period of time that was not reached in five days.

Future researchers may want to increase the discrepancy between the high practice level condition and the low practice level conditions. One way to do this would be to reduce time allotted for the low practice level. However, since there was not a significant difference between the high and no practice levels, future research should instead consider increasing the time allotted for the high practice level condition. Additionally, increasing the number of days sessions are run would also allow researchers to enhance the discrepancy between practice opportunities on high and low practice level conditions.

The error on Day 6, in which the intervention times were reversed, could have had a significant influence on the results. Since the low practice level list was practiced for 2 minutes and the high practice level list was practiced for 30 seconds, the combined effect would be in the opposite direction of what was hypothesized for the study. This methodological error led to a decrease in the discrepancy between opportunities to respond to the high and low practice level items. Although this methodological limitation is serious, the increase in the no practice items suggests that it did not account for the failure to find significant differences.

Future research should also measure retention. Ebbinghaus (1885/1964) has shown that more practice leads to better recall as time passes. Therefore, even though there were no immediate significant differences in performance across practice levels, over time these differences might be found. Future researchers should consider conducting assessments 3 to 6 months after the interventions to determine if enhanced opportunities to respond enhance generalized performance over time.

*Threats to external validity.* The current study has several external validity limitations. The participants in the study were students attending a magnet school with a focus on technology and their parents made an effort to enroll them in this program. Thus, these parents may have been more involved and vested in their children's education. Additionally, they may place more of an emphasis on mathematics. These influences may effect their children's motivation. Thus, the current students may have reacted differently than general education students not enrolled in the magnet classes. Future researchers should conduct similar studies with general education students to extend the external validity of the current findings.

The 3rd-grade was chosen for this study, because the teachers reported that their students were beginning to learn multiplication. However, mean pretest scores (e.g., 75-83% accuracy) suggest that many had already acquired multiplication facts. It is possible the amount of information already known influenced these findings (e.g. ceiling effects). Future researchers might consider using younger students who had less exposure to multiplication facts in order to obtain better practice effects.

Previous research using the CCC intervention to enhance mathematics performance have used students with disabilities (Skinner, Bamberg, Smith, & Powell, 1993; Skinner, Belfiore, & Pierce, 1992; Skinner, Turco, Rasavage, & Beatty, 1989). It is possible that CCC does not work as well with other student populations. Future researchers should conduct similar studies across populations to determine if varying levels of practice have different effects across groups.

*Summary – Theoretical and Applied Implications*

The failure to find significant interaction effects and limitations associated with the current study prevent drawing any strong conclusions. However, the current study does have both applied and theoretical implications that should be investigated by future researchers.

Researchers have found that increasing opportunities to respond enhance fluency and maintenance. The current study sought to extend this research by determining if increasing opportunities to respond would enhance generalization. In the current study, increasing multiplication practice did not enhance division performance. Thus, these findings failed to support the hypothesis that more practice enhances students' ability to generalize learning across tasks.

Future researchers need to focus on the causal relationship between practice, fluency, generalization, and adaptation. Future researchers also need to focus on the effects of daily assessment and goal setting during the CCC intervention. Previous researchers have used daily assessment in conjunction with the CCC procedure. This may have lead to the level of fluency not found by this study. In addition, goal setting could also increase the level of fluency.

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# Parental Consent Form

Dear Parent,

My name is Joshua Booher, I am a graduate student in School Psychology at the University of Tennessee. I am currently conducting a study to determine whether a student's improvement in multiplication performance will improve the student's performance in related division facts. I am writing to ask your permission for your son or daughter to participate.

If you agree to allow your child to participate, he or she will be asked to take three tests of multiplication and division performance and to perform daily worksheets of multiplication facts. The daily worksheets will be single factor by single factor multiplication problems. The tests will cover the facts on the daily worksheets and the corresponding division problems.

After your child has completed a set of worksheets or finished a test, I will score the sheets for overall performance of your child's ability with multiplication and division problems. Your child will not receive feedback on how he/she did on the worksheets. I will not ask for any information specific to your child and his/her grades. The project will require thirty minutes per mathematics class period for ten sequential days. I have spoken with your child's teacher and she does not believe that this study will interfere with your child's ability to earn grades during the time-frame of the study.

This study is voluntary, which means you can request that your child not participate or stop their participation at any time. All data and information collected will be held confidential. Your consent form will be stored in an office at the University of Tennessee for three years following completion of the project. Although results of our research may be shared with others through professional publications or presentation, your child's name will never be released.

If you have any questions about this consent or the study, please feel free to contact me at 865-363-1000, or Dr. Christopher Skinner at 865-974-8403. If you agree to allow your child to participate in this research, please check the appropriate box and sign the form provided below in the space reserved form parental/ legal guardian signature. Your help is deeply appreciated.

Sincerely,

Joshua D. Booher
Department of Educational Psychology
University of Tennessee
865-363-1000

---

☐ I **DO** agree to allow my child to participate in the research described above.

Child's name:______________________________________________

Signature of Parent/ Legal Guardian: ________________________________ Date: __________

# B. Problem Sets

Set A

| | |
|---|---|
| 2 x 5 = 10 | 2 x 9 = 18 |
| 3 x 4 = 12 | 3 x 8 = 24 |
| 4 x 7 = 28 | 5 x 6 = 30 |
| 5 x 8 = 40 | 6 x 8 = 48 |
| 6 x 9 = 54 | 7 x 7 = 49 |

Set B

| | |
|---|---|
| 2 x 3 = 6 | 2 x 7 = 14 |
| 2 x 8 = 16 | 3 x 6 = 18 |
| 3 x 9 = 27 | 4 x 6 = 24 |
| 5 x 7 = 35 | 5 x 9 = 45 |
| 7 x 8 = 56 | 8 x 9 = 72 |

Set C

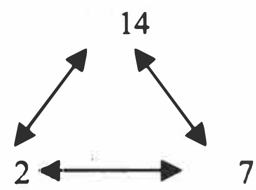
| | |
|---|---|
| 2 x 4 = 8 | 2 x 6 = 12 |
| 3 x 5 = 15 | 3 x 7 = 21 |
| 4 x 5 = 20 | 4 x 8 = 32 |
| 4 x 9 = 36 | 6 x 7 = 42 |
| 7 x 9 = 63 | 8 x 8 = 64 |

Sequence Of Events

1) Day 1 – Pretest
2) Day 2 – Initial CCC Training
3) Day 3 – CCC Intervention
4) Day 4 – CCC Intervention
5) Day 5 – CCC Intervention
6) Day 6 – CCC Intervention
7) Day 7 – CCC Intervention
8) Day 8 – Posttest 1
9) Day 9 – Training To Generalize
10) Day 10 – Posttest 2

# D. Fact Family Presentation

## Fact Family




Multiplication:

- If you begin with the 2 and move counterclockwise around the triangle, it is multiplication. (2 x 7 = 14)
- If you begin with the 7 and move clockwise around the triangle, it is multiplication. (7 x 2 = 14)

Division:

- If you begin with the 14 and move either direction around the triangle, it is division. (14 ÷ 7 = 2 or 14 ÷ 2 = 7)

The fact families are based on the three numbers you already know from the multiplication facts you have been learning.

E. Treatment Integrity Check Sheet

## Treatment Integrity

### CCC Training

___ 1) Was an overhead used for the training

___ 2) Were the five steps taught in the correct order

___ 3) Were two problems demonstrated being performed correctly

___ 4) Was one problem demonstrated being performed incorrectly

___ 5) Were all questions answered

### Assessments

___ 1) Was the correct assessment handed out ___ ___ ___ ___ ___ ___

___ 2) Were the instructions read correctly ___ ___ ___ ___ ___ ___

___ 3) Were the subjects only allowed 60 seconds ___ ___ ___ ___ ___ ___

___ 4) Were all sheets collected ___ ___ ___ ___ ___ ___

### Intervention

___ 1) Were the students handed their correct packets

___ 2) The experimenter checked to see if everyone had a working pencil ___ ___

___ 3) Were the subjects told which packet to remove from their packet ___ ___

___ 4) Were the subjects only allowed the correct time limits ___ ___

___ 5) Did the experimenter walk around the room and monitor the students ___ ___

### Generalization Training

___ 1) Did the experimenter define multiplication and division

___ 2) Did the experimenter explain the relationship between multiplication and division

___ 3) Did the experimenter show how to use the fact triangle to perform multiplication and division

___ 4) Were all questions answered

F. A Scored Intervention Sheet

C

Date 3
Time 2 min
# Attempted 8
# Correct 8
% Correct 100
DC/M ___________

7 x 6 = 42 7x6=42

2 x 4 = 8 2x4=8

4 x 5 = 20 4x5=20

5 x 3 = 15 5x3=15

9 x 4 = 36 9x4=36

7 x 9 = 63 7x9=63

4 x 8 = 32 4x8=42 4x8=32 4x8=32 4x8=32
4x8=32

6 x 2 = 12 6x2=12

7 x 3 = 21

8 x 8 = 64

G. A Copy Of The Accepted IRB Application

FORM B: APPLICATION

All applicants are encouraged to read the Form B guidelines. If you have any questions as you develop your Form B, contact you Departmental Review Committee (DRC) or the Compliances Section of the Office of Research.

FORM B

IRB# ____________________________

Date Received in OR _______________

THE UNIVERSITY OF TENNESSEE
Application for Review of Research Involving Human Subjects

I. IDENTIFICATION OF PROJECT

**1. Principal Investigator**
Joshua D. Booher
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**Co-Principal Investigator**
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**Faculty Advisor**
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Knoxville, TN 37996-3400
865-974-8403
cskinne1@utk.edu

**Department:** Department of Educational Psychology

**2. Project Classification:** Research Project

**3. Title of Project:** Task Generalization From Multiplication To Division

**4. Starting Date:** December 1, 2001 contingent upon IRB approval

**5. Estimated Completion Date:** December 21, 2002

**6. External Funding:** None

II. PROJECT OBJECTIVES:

This research is being conducted to determine if practice and improved performance with multiplication facts will generalize to improved performance with division facts. Previous research demonstrates that practice increases generalization across settings and across time. However, no research to date has shown generalization across tasks.

III. DESCRIPTION AND SOURCE OF RESEARCH PARTICIPANTS

The participants in this research will include elementary school students enrolled at Sarah Moore Greene Magnet Technical Academy. Participation will be solicited from approximately 40 third grade students (2 classrooms) and their parents and/or guardians.

IV. METHODS AND PROCEDURES

Joshua Booher, a doctoral student in school psychology, will prepare packets for usage by the participating students. These packets will contain three sets (Sets A, B, C) of intervention sheets. These intervention sheets will include ten multiplication facts (e.g. 4 x 6 = 24) down the left hand side. On the top right hand side of the page will be places for the student's number (random blind assignment), date, time (number of seconds taken to complete the sheet), digits correct per minute, errors per minute, and percent of problems correct. A similar set of sheets will be generated for assessment. However, these sheets will not include the answers to the multiplication problems.

In order to protect the participants' identities, each participant will be assigned a number before the study begins. This is to ensure that the pretest, intervention, and posttests of each participant are matched for analysis purposes. However, only the teachers will know which participant is assigned which number.

On the first of the ten sequential school days, a pretest will be given to all participants. On the second day, the participants will be instructed on how to perform the intervention using the intervention sheets. For the third through seventh days, the intervention will be performed. During the intervention days, students will practice the first set of sheets daily for four minutes, the second set of sheets for one minute, and will not practice with the third set of sheets. The sets of sheets will be counterbalanced across students and the order of practice will be counterbalanced across days. Daily data will be collected on how many digits the participants get correct per minute, how many errors they make per minute, and what percent of attempted problems they get correct. On the eighth day, a posttest will be given to assess the level of generalization that occurred from multiplication facts to division facts. (The division pretest and posttest will be created identically to the multiplication pretest and posttest, but will have the corresponding division problems.) On the ninth day, the students will be taught generalization techniques and on the tenth day will then be assessed one last time. Generalization will be taught using fact triangles.

The total time for participation will be thirty minutes per class day for two weeks. This time will occur during the participants' regularly schedule mathematics class, or at another time preferred by the classroom teachers. Single-subject (i.e., alternating treatments) and elements of group (within-subject repeated measures ANOVA) designs will be used to assess the level of generalization that occurs. Non-participating students will complete their typical mathematics assignment as assigned by their classroom teacher.

At the teachers' request, all work will be performed by all the students in the classrooms. However, only the students who agree to participate will be scored for data collection purposes. The packets of non-participating students will be left with the teachers. In addition, due to the limited time frame the study will require daily, relative to the time they allot for mathematics instruction, the teachers are not concerned about possible lost opportunities for participants earning classroom grades.

V. SPECIFIC RISKS AND PROTECTION MEASURES

Confidentiality will be maintained at all times. The students will be assigned a number, which the investigators will not know. The number will only be used to match worksheets and tests across days. There are no other foreseen risks involved. In addition, administrators and the classroom teachers will be able to halt procedures if unforeseen risks occur.

VI. BENEFITS

We may learn how to enhance students' performance in one academic task by having them practice more in a related, but different task.

VII. METHODS FOR OBTAINING "INFORMED CONSENT" FROM PARTICIPANTS

The classroom teacher(s) will give informed consent forms to the students for delivery to parents (see attached). After their parents have signed it, the participating students will return the form to school. Completed consent forms will be stored and maintained for three years in the office of the co-principal investigator following completion of the study. Students from whom consent was not obtained will remain in the classroom during data collection. No data or identifying information will be collected on these students. Instead of participating in the study, these students will complete their typical classroom assignment selected by the classroom teacher. All participating students in the classroom will be completing worksheets independently at their desks. Therefore students participating in research will not disrupt non-participating students and non-participating students will not disrupt students completing worksheets for the research project. Students who do not participate will not be penalized in any way.

VIII. QUALIFICATIONS OF THE INVESTIGATOR(S) TO CONDUCT RESEARCH

Dr. Skinner was a master teacher in a self-contained school for students with behavioral disorders and has conducted and published over 10 studies using procedures similar to those used in the present study. Joshua Booher is currently enrolled in a graduate program leading to the Ph.D. in education with a concentration in School Psychology. He has previously earned a M.S. in Mental Health Counseling and an Ed.S. in School Counseling.

IX. FACILITIES AND EQUIPMENT TO BE USED IN THE RESEARCH

Worksheets, paper, pencils, and photocopier all located at the University of Tennessee-Knoxville, within the College Of Education, will be used in the completion of this study. Following approval, procedures will be completed at Sarah Moore Greene Magnet Technology Academy.

X. RESPONSIBILITY OF THE PRINCIPAL/ CO-PRINCIPAL INVESTIGATOR(S)

Through compliance with the policies established by the Institutional Review Board of The University of Tennessee, the principal/ co-principal investigator(s) subscribe to the principles stated in "The Belmont Report" and standards of professional ethics in all research, development, and related activities involving human subjects under the auspices of The University of Tennessee. The principal/ co-principal investigator(s) further agree that:

1. Approval will be obtained from the Institutional Review Board prior to instituting any change in this research project.
2. Development of any unexpected risks will be immediately reported to the Compliances Section.
3. An annual review and progress report (Form R) will be completed and submitted when requested by the Institutional Review Board.
4. Signed informed consent documents will be kept for the duration of the project and for at least three years thereafter at a location approved by the Institutional Review Board.

XI. SIGNATURES

Principal Investigator: Joshua D. Booher

Signature: ______________________________ Date: ________________________

Co-Principal Investigator: Christopher Skinner

Signature: ______________________________ Date: ________________________

XII. DEPARTMENT REVIEW AND APPROVAL

The application described above has been reviewed by the IRB departmental review committee and has been approved. The DRC further recommends that this application be reviewed as:

[x] Expedited Review—Category(ies): 7

OR

[ ] Full IRB Review

Chair, DRC: Robert Williams

Signature: ____________________________ Date: _______________________

Department Head: R. Steve McCallum

Signature: ____________________________ Date: _______________________

Protocol sent to Compliance Section for final approval on (Date): ___________________

Approved:

Compliance Section

Office of Research

404 Andy Holt Tower

Signature: ____________________________ Date: _______________________

For additional information on Form B, contact Brenda Lawson by email at blawson@utk.edu or by phone at 974-7697.

References

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**Parental Consent Form**

Dear Parent,

My name is Joshua Booher, I am a graduate student in School Psychology at the University of Tennessee. I am currently conducting a study to determine whether a student's improvement in multiplication performance will improve the student's performance in related division facts. I am writing to ask your permission for your son or daughter to participate.

If you agree to allow your child to participate, he or she will be asked to take three tests of multiplication and division performance and to perform daily worksheets of multiplication facts. The daily worksheets will be single factor by single factor multiplication problems. The tests will cover the facts on the daily worksheets and the corresponding division problems.

After your child has completed a set of worksheets or finished a test, I will score the sheets for overall performance of your child's ability with multiplication and division problems. Your child will not receive feedback on how he/she did on the worksheets. I will not ask for any information specific to your child and his/her grades. The project will require thirty minutes per mathematics class period for ten sequential days. I have spoken with your child's teacher and she does not believe that this study will interfere with your child's ability to earn grades during the time-frame of the study.

This study is voluntary, which means you can request that your child not participate or stop their participation at any time. All data and information collected will be held confidential. Your consent form will be stored in an office at the University of Tennessee for three years following completion of the project. Although results of our research may be shared with others through professional publications or presentation, your child's name will never be released.

If you have any questions about this consent or the study, please feel free to contact me at 865-363-1000, or Dr. Christopher Skinner at 865-974-8403. If you agree to allow your child to participate in this research, please check the appropriate box and sign the form provided below in the space reserved form parental/ legal guardian signature. Your help is deeply appreciated.

Sincerely,

Joshua D. Booher
Department of Educational Psychology
University of Tennessee
865-363-1000

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☐ I **DO** agree to allow my child to participate in the research described above.

Child's name:______________________________________________

Signature of Parent/ Legal Guardian: ______________________________ Date: _________

Vita

Joshua David Booher was born in Bethesda, MD in December, 1971. He graduated from the Mississippi School of Math and Science in 1990. From there, he went to the University of the South in Sewanee, TN and received a B.A. in psychology in 1994. He received an M.S. in Counseling and an Ed.S. in School Counseling from the University of Tennessee, Knoxville.