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The effects of peer practice on fluency of basic multiplication facts and generality to complex problems by high school students

Miller, April Denise, Ph.D.

The Ohio State University, 1992
THE EFFECTS OF PEER PRACTICE ON FLUENCY
OF BASIC MULTIPLICATION FACTS AND GENERALITY
TO COMPLEX PROBLEMS BY HIGH SCHOOL STUDENTS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by

April Denise Miller, B.S., M.A.

* * * * *

The Ohio State University
1992

Dissertation Committee:
Dr. Timothy E. Heron
Dr. John O. Cooper
Dr. William L. Heward
Dr. Deborah Tannehill

Approved by
Advisor
Department of Educational
Services and Research
College of Education
To Craig,

for his constant love and support.
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April 11, 1961....................................................Born - McKeesport, Pennsylvania

1983.................................................................B.S. Ed., The Ohio State University, Columbus, Ohio

1983 - 1984....................................................Teacher, Learning Disabled and Educable Mentally Handicapped, Boone County, Florence, Kentucky

1988.................................................................M.A. Ed., The Ohio State University, Columbus, Ohio


1989 - 1990....................................................Ph. D. Traineeship, Leadership Training Program, Division of Personnel Preparation, Office of Special Education and Rehabilitation Services, United States Department of Education

1990 - 1992....................................................Graduate Research Assistant, The Ohio State University, Columbus, Ohio
PUBLICATIONS


FIELDS OF STUDY

Major Field: Education

# TABLE OF CONTENTS

DEDICATION .............................................................................................................................. ii

ACKNOWLEDGMENTS ........................................................................................................ iii

VITA ............................................................................................................................................ iv

LIST OF TABLES ...................................................................................................................... x

LIST OF FIGURES ................................................................................................................... xi

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. INTRODUCTION ................................................................. 1</td>
<td></td>
</tr>
<tr>
<td>Glossary of Terms ................................................................. 6</td>
<td></td>
</tr>
<tr>
<td>Statement of the Problem ......................................................... 8</td>
<td></td>
</tr>
<tr>
<td>Research Questions ................................................................. 8</td>
<td></td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE ............................................ 10</td>
<td></td>
</tr>
<tr>
<td>Mathematics Instruction ......................................................... 10</td>
<td></td>
</tr>
<tr>
<td>Curriculum and Evaluation Standards for School Mathematics ............ 11</td>
<td></td>
</tr>
<tr>
<td>Math Fluency ................................................................. 13</td>
<td></td>
</tr>
<tr>
<td>Time Trials ................................................................. 15</td>
<td></td>
</tr>
<tr>
<td>Opportunity to Respond ......................................................... 18</td>
<td></td>
</tr>
<tr>
<td>The Effective Use of Students as Instructional Agents ............ 20</td>
<td></td>
</tr>
<tr>
<td>Tutoring: Formats and Procedures ........................................... 25</td>
<td></td>
</tr>
<tr>
<td>Classwide Peer Tutoring Systems .......................................... 26</td>
<td></td>
</tr>
<tr>
<td>Cross-Aged Tutoring ......................................................... 30</td>
<td></td>
</tr>
<tr>
<td>One-to-One Tutoring ......................................................... 32</td>
<td></td>
</tr>
<tr>
<td>Home-Based Tutoring ......................................................... 33</td>
<td></td>
</tr>
<tr>
<td>Students Selected for Tutoring Research ................................... 34</td>
<td></td>
</tr>
<tr>
<td>Tutoring Outcomes ............................................................... 37</td>
<td></td>
</tr>
<tr>
<td>Methodological Procedures ................................................... 39</td>
<td></td>
</tr>
<tr>
<td>Monitoring and Evaluation .................................................... 44</td>
<td></td>
</tr>
<tr>
<td>Component Analysis .............................................................. 47</td>
<td></td>
</tr>
<tr>
<td>Implications for Classroom Teachers ....................................... 48</td>
<td></td>
</tr>
<tr>
<td>Implications for Teacher Educators ......................................... 50</td>
<td></td>
</tr>
</tbody>
</table>
### Implications for the Researcher

- 50

### Summary and Conclusions of Tutoring Literature

- 52

### Generality of Behavior Change

- 53

### Social Validation

- 55

## III. METHOD

### Subjects

- 57

### Setting

- 58

### Experimenter

- 60

### Observers

- 60

### Definition and Measurement of the Dependent Variables

- 61

#### Rate of Digits Correct

- 61

#### Percentage of Digits Correct

- 62

#### Rate of Digits Correct During Peer Practice

- 62

#### Accuracy Checks on Math Data Reporting

- 64

### Definition and Measurement of the Independent Variables

- 64

### Procedural Agreement Measures

- 65

### Generality Measures

- 65

### Maintenance Measures

- 66

### Social Validity

- 66

### Materials

- 67

### Experimental Design

- 71

### Procedure

- 71

#### General Experimental Procedure

- 71

#### Student Assessment

- 72

#### Timed Tests

- 72

#### Feedback to the Students

- 74

#### Tutoring Procedure

- 75

#### Partner-Administered Time Trial Procedure

- 79

#### Experimenter’s Role

- 83

## IV. RESULTS

### Interobserver Agreement Scores

- 84

### Procedural Reliability

- 84

### Rate of Digits Correct During Peer Practice

- 85

### Rate and Percentage of Digits Correct on Complex Multiplication Problems

- 88

### Rate of Digits Correct During Peer Practice

- 88

#### Student 1

- 88

#### Student 2

- 91

#### Student 3

- 92

#### Student 4

- 92


LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Student Characteristics</td>
<td>59</td>
</tr>
<tr>
<td>2. Procedural Interobserver Agreement for Peer Tutoring and Time Trials</td>
<td>86</td>
</tr>
<tr>
<td>3. Interobserver Agreement Scores for Rate of Digits Correct During Practice for Each Experimental Condition</td>
<td>87</td>
</tr>
<tr>
<td>4. Interobserver Agreement Scores for Complex Multiplication Problems for Each Experimental Condition</td>
<td>89</td>
</tr>
<tr>
<td>5. Mean Rate and Percentage of Digits Correct on Complex Multiplication Problems for Each Experimental Condition</td>
<td>116</td>
</tr>
<tr>
<td>6. Mean Number, Rate, and Percentage of Problems Correct on Complex Problems for Each Experimental Condition</td>
<td>117</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate of digits correct during practice</td>
<td>90</td>
</tr>
<tr>
<td>2. Rate of digits correct and incorrect on complex multiplication tests</td>
<td>98</td>
</tr>
<tr>
<td>3. Percentage of digits correct on complex multiplication problems</td>
<td>109</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

In the last 15 years, education professionals have been required to provide full service on limited budgets and resources, to do so faster and more efficiently, and to provide services to greater numbers of children, than ever before. School systems, taxpayers, and teachers have become acutely aware of the difficulties of providing adequate services to meet the needs of students who have been identified as at-risk but who do not qualify for special services.

Recently, economic cutbacks have seemingly become the norm and have led to reductions in instructional personnel and classroom aides, fewer opportunities for teacher inservice, and less purchasing power for instructional materials. At the same time, several reports (National Commission on Excellence in Education, 1983; Holmes Group, 1990) have outlined problems in the American educational system and have recommended sweeping changes to reduce these problems. The reports call for reforms such as longer school days, increased amounts of homework, improvement of student performance levels, increased use of proficiency testing, extension of teacher preparation programs, and Professional Development Schools. The effect of these reports on education is likely to be profound, with changes in teacher training, teaching methods, and the amount of time students spend engaged in academic learning. This increased emphasis on achievement and the simultaneous budgetary constraints have profound implications for all teachers.
Individualized instruction is an important strategy for improving student academic achievement, and is one of the more difficult tasks teachers face on a daily basis. Teachers recognize the need for more individualized instruction for their students, but this objective can be difficult to accomplish because of the number of students they teach and an orientation to teach to the group.

Individualized learning and educational plans call for instruction of students to be tailored to the needs of the student. This means that each student will have a specifically designed curriculum and will progress through that curriculum to meet the goals identified for that student. Modifications may include curriculum adaptations, changes in the presentation or response mode required, and the use of technology (Heron & Harris, 1987).

Individualized instruction also requires that students be taught with a teacher-student ratio that provides the best learning situation for the student. Various student grouping arrangements, large and small group arrangements for example, have helped teachers better individualize instruction for students. Practitioners, however, face with higher student-teacher ratios, a greater percentage of students in need of more help or at-risk of failure, and virtually no external assistance from outside the classrooms. As one solution, teachers have recruited volunteers; but even this option has become less likely as more parents and community members work outside the home. Over the past 20 years, there has been an increasing number of single parents, dissolution of the extended family, and more women choose, or are forced, to work outside the home (Field, 1981), leaving little time to volunteer at school.

Another challenge for teachers who provide individualized attention is to keep students actively engaged with instructional materials. For example, when
a teacher works with a small group or provides a child with one-to-one instruction, other groups of students who should be working independently may demonstrate off-task or low productivity behavior. In this case, an increased use of peers as agents for behavioral and instructional change with these children provides a partial solution to this dilemma.

In the education of children with disabilities and those at-risk, the goals are the programming of effective instruction and the arranging of contingencies that result in rapid student progress through positive outcomes. Applied behavior analysis has been a key in attaining these goals. Cooper, Heron, and Heward (1987) define applied behavior analysis as "the science in which procedures derived from the principles of behavior are systematically applied to improve socially significant behavior to a meaningful degree and to demonstrate experimentally that the procedures employed were responsible for the improvement in behavior" (p. 15).

Another important aspect of instruction is the guidelines teachers use to determine mastery of the skills the student is expected to learn. The criterion on which mastery of a skill is based is important for determining how long a student should work on a skill. Most often, teachers have no specific criteria for student mastery of specific skills. Skills are introduced, practiced, and after a sufficient amount of time is spent on the skill, the next skill is introduced. In this situation, the students are expected to learn the information or the skill within the time allotted. A summative test is used to determine whether or not the skill is mastered. This "calendar driven" model of curriculum allows teachers to assign grades to students based on their performance, yet all students are moved
through the curriculum together, whether or not the skill is mastered. Little or no individualization results from failure to master a skill.

Most teachers base mastery of a skill on the accuracy or percent correct of the performance. Mastery is determined by a set percentage criterion. Students are awarded grades based on percentages, with a range of percentages being acceptable and another range unacceptable. These grades are then used to determine if the student will pass on to the next grade level. In special education, teachers are required to state additional conditions of mastery, and criteria may include additional conditions of the antecedent. For example, "The student will achieve 95% accuracy on a weekly spelling test of 20 words." Or, "Given a worksheet of 2-digit addition problems, the student will complete the 25 problems within 10 minutes, with 90% accuracy." Special educators have been more systematic about assessing skills and determining what skill will be taught next, but the question of what performance level determines mastery must still be asked.

Rarely do teachers include conditions specifically stating the rate at which the target behavior must be performed. Rate per minute provides a more sensitive measure of performance, than do accuracy measures alone (Howell & Lorson-Howell, 1990). Two students may perform a skill with equal accuracy, but if one takes 15 minutes to complete the task as compared to 1 minute by the other student, clearly they have different levels of mastery of the skill. Rate of performance, or fluency, should be part of assessing student progress (Howell & Lorson-Howell, 1990).

In most classrooms, mastery of an individual skill is not used to determine what will be taught next, or if remedial instruction in a skill area is necessary.
students are expected to succeed and be contributing members of society and the work force, provisions for mastery of skills by students must be addressed and instructional decisions must be made on an individual basis.

Peer tutoring programs have been found to be a successful and cost effective method for providing individualized instruction for students of varying skill levels (Drass & Jones, 1971; Ehly & Larson, 1980; Heron, Heward, Cooke, & Hill, 1983; McKellar, 1986) and for providing maximum opportunities to respond (Heron et al., 1983; Delquadri, Greenwood, Whorton, Carta, & Hall, 1986). Tutoring has been used to produce academic improvement in mathematics (Barbetta & Heron, 1991; Franca, Kerr, Reitz, & Lambert, 1990; Greenfield & McNeil, 1987; Kane & Alley, 1980; Maher, 1984; McKenzie & Budd, 1981; Pigott, Fantuzzo, & Clement, 1986; Roach, Paolucci-Whitcomb, Meyers, & Duncan, 1983; and Thurston & Dasta, 1990; Vacc & Cannon, 1991) as well as in many other academic areas.

Adequate social skills are extremely important for the independent survival of the student with learning problems. Students with disabilities, especially learning disabilities, experience social problems in school (Heron & Harris, 1987). Inappropriate behaviors and social skills often accompany or compound the learning problems of students. These students will face a great number of challenges as they enter the mainstream of society. The more skills that they have for dealing and relating with other people, the better they will fare. Specific training and development of social skills are necessary.

Peer tutoring in the classroom is an excellent way to take advantage of improving and reinforcing these much needed social skills. The benefits of tutoring include improved social skills (Ehly & Larson, 1976), increased social
interaction time (Custer & Osguthorpe, 1983), and more positive attitude toward school (Devin-Sheehan et al., 1976). Along with these benefits to the teacher and student, tutors have been trained to use intermittent positive reinforcement to sustain the effort of their students (Heward, Heron, Ellis, & Cooke, 1986). Positive reinforcement has been used effectively by special educators to bring about behavior change. Verbal social praise is not intrusive and is used commonly by many people. Using social reinforcement lead the students to engage in more social behaviors, which in turn, reinforce the student, thus creating a sustaining "behavior trap."

As our society becomes more complex and technically oriented, expectations rise for all students of our society to become independent, contributors to our society. Mathematics ability is very important for this expected level of everyday, independent functioning. Without mathematics skills, one is at a distinct disadvantage. A mathematics program must be geared to the student's abilities, and be designed to meet his or her interests and needs for the future. Students must at least have a basic understanding of mathematics skills on a conceptual level (NCTM Standards, 1989). Basic multiplication facts is one component of the knowledge base for further mathematics skill development.

GLOSSARY OF TERMS

The following terms were used to describe behaviors and procedures in this study. They were defined to clarify the operational use of the terms.

ACCURACY -- The number correct divided by the total number, multiplied by 100. Responses in this study were measured in percentage correct to represent the accuracy of the performance.
DIGITS PER MINUTE -- The number of numerals written per minute when solving calculation problems. For example, 5743 written by a student was counted as 4 digits written. To calculate the digits per minute, the digits written were counted and divided by the amount of time allocated for the student to work. For example, 187 digits written during the 3 minutes was calculated as 62.3 digits per minute.

FLUENCY -- Refers to the accuracy of responses and the speed at which those responses were made. Fluency described an instructional outcome, and was measured by correct rate.

PEER PRACTICE -- The addition of practice time prior to the test of complex multiplication problems. Practice was administered by another student rather than by the experimenter. Two peer practice methods were used: peer tutoring and time trials.

PERCENT CORRECT -- The number of correct responses divided by the total number of responses, multiplied by 100. The responses counted in this study were digits per minute.

PROBLEMS CORRECT -- The number of problems solved correctly divided by the total number of problems completely solved, multiplied by 100. Problems partially solved were not included in the total number of problems solved.

RATE -- The speed of the response. In this study, rate correct was calculated by dividing the number of correct responses by the amount of time allowed for responding. For example, 12 problems were solved correctly in 3 minutes, a rate correct of 4 problems per minute was obtained. Rate incorrect data were calculated by dividing the number of incorrect
responses by the amount of time allowed for responding. For example, 3 problems solved incorrectly in 3 minutes yielded a rate incorrect of 1 problem per minute. Rate was always reported as rate per minute.

SIGNIFICANT -- A change that makes a noticeable difference in the every day functioning or performance of the student. This does not refer to a predetermined level of difference in student performance scores.

VERBAL PRAISE -- Statements made to the students by the experimenter or peer partner, to recognize correct performance or behavior. For example, "Nice work" or "You're going faster, now."

STATEMENT OF THE PROBLEM

This study was conducted to determine the effects of peer practice on multiplication fact acquisition and response generality from basic multiplication facts practiced during peer tutoring and time trials to the use of these facts in more complex multiplication problems. Specifically, it was anticipated that the increased number of opportunities to respond would increase the rate and percentage of correct digits on complex multiplication problems. Other concerns of the study included the students' attitudes toward the program, and the visibility of change created by the program to other staff in the building, especially the math teachers of the students.

RESEARCH QUESTIONS

The specific research questions investigated by the study are listed below.

1. Will high school students' fluency on complex multiplication problems change as a function of peer practice on basic multiplication facts?
2. Is there a relation between student rate of digits correct during practice during peer practice and their rate of digits correct on complex multiplication problems?

3. Will any other staff members in the building notice changes in student behavior or math performance because of the program?

4. What are the students' opinions of the math fact peer practice program?
CHAPTER II
REVIEW OF THE LITERATURE

This chapter defines and reviews the research literature pertaining to the teaching of mathematics and focuses on peer tutoring and time trials as instructional methods for building fluency and increasing the number of opportunities in which students are required to respond. Different tutoring methods will be compared and contrasted with regard to training, outcomes, and evaluation. Interpretation of the literature and implications and recommendations for the classroom teacher, teacher educators, and researchers are offered. Social validity and generality of behavior will also be addressed.

MATHEMATICS INSTRUCTION

Daily living requires the application of mathematics skills. Planning and monitoring time, computing the cost of sale items, making estimations of number or distance, interpreting recipe measurements, measuring for carpet purchases, computing scores in games, handling money and bank transactions, and maintaining a checkbook are but a few examples of how mathematics is applied in everyday life. The importance of providing effective instruction for students with math disabilities is apparent; however, the challenge of improving instruction for these students intensifies when reviewing the reforms being proposed for mathematics education (Mercer & Miller, 1992).
The National Council of Supervisors of Mathematics (1988) and the National Council of Teachers of Mathematics (1989) have called for reforms in math education that endorse higher standards of math achievement. Reforms that produce higher standards are certain to frustrate teachers and students who struggle with current standards and the traditional curriculum (Mercer & Miller, 1992). Mercer and Miller (1992) state that the learning difficulties of students are often compounded by ineffective instruction. Carnine (1991) believes that "traditional instruction" is a primary cause of math problems of many of the students with learning problems. Given the poor math progress of many students now in the schools and the reform movement in mathematics education to increase curriculum standards, a need exists for a more effectively designed mathematics instruction for students with difficulties in math.

Curriculum and Evaluation Standards for School Mathematics

In 1989, the National Council of Teachers of Mathematics presented a set of Curriculum and Evaluation Standards for School Mathematics to be used as a guideline in the revision of the school mathematics teaching curriculum in grades K through 12. The Standards are statements that "can be used to judge the quality of a mathematics curriculum or methods of evaluation" (p.2) and were developed as "one facet of the mathematics education community's response to the call for reform in the teaching and learning of mathematics" (p.1).

The Standards define five general goals for all students in grades K-12: (a) students will learn the value of mathematics, (b) they will become confident in their ability to do mathematics, (c) they will become mathematical problem solvers, (d) they will learn to communicate mathematically, and (e) they will
learn to reason mathematically. These goals imply students should be exposed to numerous and varied integrated experiences in mathematics.

Of major importance is the goal for students to become confident in their ability to do mathematics. The Standards state that "As a result of studying mathematics, students need to view themselves as capable of using their growing mathematical power to make sense of new problem situations in the world around them." (p. 6). In order for students to feel confident about their mathematical abilities, the Standards suggest children should be actively involved with the curriculum and with "doing" math. The experiences gained during mathematics instruction will later help students to apply their skills in new situations.

Although it may seem obvious, what is meant by "confidence" is left undefined in the Standards. Binder (1990) defined confidence as the ability to perform an act without hesitation, smoothly, correctly and with a feeling of accomplishment. He further stated that confidence is a matter of pace or quickness of response, as well as correctness or accuracy. In order to gain a complete picture of the performance, it is necessary to measure how quickly the learner is able to perform criterion tasks and skills. Without knowledge of learner performance rates, it is impossible to be sure the skill is mastered.

The Standards emphasize increased attention to help students develop confidence about their mathematical powers, yet there is also a decreased emphasis on instructional practices that use rote practice, memorization of rules, mental math, and the use of written practice. These same, or similar instructional practices, have been shown in the behavioral literature to build fluency resulting in increased student confidence (Binder, 1988), and also have
been related to a lengthened attention span (Binder 1987), the maintenance of skills (Ivarie, 1986), and better application of the skill within more complex problem solutions (Van Houten, 1980).

**Math Fluency**

Each day in classrooms across the country substantial numbers of students practice their math facts. Teachers usually provide feedback to the students in terms of a percentage score, the number correct divided by the number of problems attempted. Accuracy is the main concern of teachers because students who are not able to add and subtract correctly, besides being unable to perform higher level math skills, are likely to face major difficulties throughout school and life.

Accuracy measures alone, however, are not enough to determine mastery of a skill. The student's proficiency, or fluency of responding, is a critical component of mastery (Cooper, Heron, & Heward, 1987). Fluency is the measure of accuracy plus speed (Binder & Watkins, 1990). Binder (1988) went so far as to say that the true definition of mastery is fluency. To be functional, many skills must be performed at a certain rate or speed, as required by the situation. In general, most curriculum and instructional design efforts ignore the time dimension, and therefore generally fail to produce fluency, or true mastery (Binder, 1987).

Fluency is an important measure of student learning. Howell and Lorson-Howell (1990) gave several reasons why a measure of fluency should be part of assessing student progress. First, rate per minute is more sensitive and provides more information about the skill performance than an accuracy measure alone. Second, fluency has implications for the functional use of the
skill, as proficient responding is required in many situations, both in and out of school. Focusing attention and effort on timing students also increases their awareness and rate of performance (Miller & Heward, in press). Fluency is also related to the maintenance and generality of skills (Ivarie, 1986; Stokes & Baer, 1977).

The use of response fluency (accuracy divided by time) is not new to the field of education. Cortis (1919) described the use of 1-minute samples of correct performance to assess children's competence in specific academic skills. Barrett (1979) provided an example of the importance of measuring fluency. She compared the performance of groups of normal adults, normal five- to seven-year olds, and institutional residents with severe retardation on counting, writing, and discrimination tasks. All three groups performed the series of tasks with essentially 100% accuracy, and differences in performance were therefore, not discriminable. When the performance of the groups was described in terms of response rates, the groups clearly differed.

In the measurement of response fluency, a measure of the duration of the practice or testing period must be taken. This measurement of time adds uniformity to assessment of student performance (White & Haring, 1980). If a student responds to 50 problems one day and 45 problems the next, it appears as if the performance of the student has decreased. But, if the first day the student was given 2 minutes, and the second day he had 1 minute, it is clear that the performance has increased (from 25 problems per minute to 45 problems per minute).
Time Trials

The explicit timing of students has been used to precisely and systematically measure and evaluate instructional tactics and curricula (West, Young, & Spooner, 1990). Using daily time trials is an excellent way to build fluency (Lovitt, 1978; Van Houten, 1980). Time trials are a drill and practice strategy that use a short work period in which students answer as many problems as possible. Most time trial procedures recommend a duration of only or two minutes. For more complex skills, the time, or counting period, can be extended.

Time trials are used easily in the classroom. Miller and Heward (in press) include general guidelines for planning and implementing time trials. The teacher assesses the students on the skills to be practiced. Worksheets of those skills to be practiced are developed by the teacher. Each day, a worksheet is timed by the teacher and scored. The resulting data are graphed and visually analyzed to determine the course of action the teacher should pursue. In just a few minutes a day, student progress and instructional tactics can be assessed with the use of time trials.

The use of time trials in mathematics has been shown to increase fluency rates. Ayllon, Garber, and Pisor (1976), for example, found that a gradual decrease of the amount of time available to work on math problems increased rates of correct responding. Three students, identified as mentally retarded, received tokens contingent on the number of correct math problems answered during the session. Abruptly, the amount of time provided to perform the math problems was decreased from 20 minutes to 5 minutes. Students' rate of responding dropped dramatically. In a reversal of the conditions, students
returned to baseline levels of responding. Next, a systematic reduction of time from 20 minutes to 15 minutes, then to 10 minutes, and to 5 minutes, was implemented. This series of gradual reductions substantially increased the rate of responding for all three students. At the end of the study, the time limit was again raised to 20 minutes without any reduction in the students' rate levels.

Van Houten and Thompson (1976) found that explicit timing of student math performances increased the rate of problems worked correctly per minute while maintaining very high baseline levels of accuracy. In baseline, 20 second grade students performed addition and subtraction problems during a 30-minute work period. An intervention of sequential 1-minute timings was implemented for the 30-minute work period. During the time trials intervention, correct rate for the class increased from 3.5 to 11.5 correct problems per minute. Accuracy during the experiment remained above 90%.

Miller, Hall, and Heward (1992) assessed the effects of 1-minute time trials on the rate and accuracy of performing math facts in a regular first grade classroom and an intermediate special education classroom. During the 10-minute baseline condition, students were asked to go as fast as they could. An intervention of seven 1-minute time trials with 20-second inter-trial rest periods was implemented. During this intervention, students in both classes improved an average of 4.1 correct problems per minute. A reversal showed student rates returning to baseline levels and when the intervention was again implemented, student response rates increased by 5 correct problems per minute. Accuracy for both classes remained high during the entire study, with a range of 84% to 92%.
Hall (1991) used time trials in combination with feedback to produce more robust changes in student performance. Twenty-five second grade students solved addition and subtraction facts during a 10-minute work period. Under the condition of seven consecutive time trials with next day feedback, students averaged 24.7 correct problems per minute, with 96.5% accuracy. A second condition implemented the use of two time trials with self-corrective feedback. In this condition, the teacher led students in self-checking their papers between the time trials. Correct rate during this condition was 32.6 problems per minute and accuracy (percentage correct) was 96.7%. A third time trial condition was implemented in which students took five consecutive 1-minute time trials with the selective grading of one of the time trials during the last 4 minutes of the session. Correct rate during this condition averaged 39.3 problems per minute, with accuracy (percentage correct) of 96.6%. The five time trials with corrective feedback condition also offered each student the most opportunities to respond, with a mean of 233.3 responses per session. Comparatively, students responded an average of 180 times per session during the seven consecutive time trials, and 131.7 times per sessions during the two time trials with corrective feedback.

Van Houten (1980) reported the results of an unpublished study by Van Houten and Sharma. In this study junior high school students, ages 12 to 16 years old, were assessed daily on a 10-minute test of complex multiplication and division problems. An intervention of basic multiplication fact drill was implemented on selected sessions. During the baseline sessions, the average number of problems correct on the test remained stable at about 2.25 correct problems per minute. When the multiplication drill was first implemented, the
correct rate on the complex problems increased to about 3.5 problems per minute. Reversals to baseline conditions resulted in stable trends showing no improvements. Each time the intervention was implemented, the trend showed an improvement and a higher mean. At the end of the study, students were correctly solving an average of about 4.6 problems per minute on the complex problems test.

During baseline conditions prior to the training, students were able to respond correctly at a rate of 30 to 40 basic multiplication facts per minute. Following training, the students correctly completed between 60 and 70 basic multiplication facts per minute during the drill portion of the class. Accuracy on the multiplication facts did not improve. Van Houten concluded that the improved rate at which students solved the basic multiplication facts was correlated with improved rate and accuracy on the complex multiplication and division problems tested.

**Opportunity to Respond**

Time trials also help students improve their fluency by providing many opportunities to respond at a fast rate (Greenwood, Delquadri, & Hall, 1984). The definition of opportunity to respond is not simply the number of chances that a student has to give an answer. Greenwood, Delquadri, and Hall (1984) defined the opportunity to respond as "the interaction between: (a) teacher formulated instructional antecedent stimuli (the materials presented, prompts, questions asked, signals to respond, etc.), and (b) their success in establishing the academic responding desired or implied by the materials" (p. 64). This definition implies that the teacher should arrange antecedent stimuli so that all students can make the desired responses, students should be placed in
learning situations in which they can emit high rates of correct responses, and the responses needs to be active academic responding (actual calculations, oral reading, answering questions, academic games, etc.) rather than passive (visual attention such as watching, listening, or waiting) responding (Barbetta, Heron, & Heward, in press).

Opportunity to respond and student responding has been researched extensively in the past 10 years. The research shows that "a necessary condition for academic achievement is an arrangement in which there is frequent interaction between teacher and/or classroom antecedents and student responding" (Delquadri et al. 1986, p. 536). Greenwood et al., (1984) describe that "the remediation of low achievement can benefit from instructional practices that provide high opportunity to respond, as students will gain more in the limited span of school time available to teach them, than will the same students in lower opportunity instructional setting" (p. 87). Another finding has shown that stimulus control associated with frequent opportunities to respond increases academic achievement (Hall, Delquadri, Greenwood, & Thurston, 1982). Whorton et al. (1986) found that opportunity to respond is functionally related to increased student academic behavior and achievement gain. Delquadri, et al. (1986) found peer tutoring to be an alternative approach for increasing classwide student responding opportunities.

The method of peer tutoring calls for the individual to respond frequently and therefore, offers the ability to accelerate the occurrence of academic behavior. This high rate activity also allows the teacher to monitor student responding and to limit the time students spend in transition, waiting, and
looking for materials. Together, these improvements over other teaching methods, maximize achievement gains of the students.

THE EFFECTIVE USE OF STUDENTS AS INSTRUCTIONAL AGENTS

The use of peers to enhance the delivery of services in schools is not a new idea (Lancaster, 1803). The peer group is the largest source of potential change agents available for influencing behavior change in children. In school settings, peers outnumber teachers, parent volunteers, and paraprofessionals. Yet, this powerful influence on both academic and social gains has often been overlooked and underutilized. Additionally, the extent to which peers have been used as behavioral and instructional change agents is difficult to determine because they have often been used in an informal manner, thus, peer mediation has not been fully reported.

There are several reasons that peers may serve as important instructional resources. First, children control a large proportion of their peers', parents' and teachers' behaviors due to the reciprocity of social interaction and the natural interplay of behavioral principles (Patterson, 1975; Becker, Engelmann, & Thomas, 1971). Social reinforcement of children by their peers occurs naturally in the classroom (Gerber & Kauffman, 1981). Consequences spontaneously provided by peers in natural settings on a daily basis modify and maintain behavior. Barker and Wright (1955) reported that contacts with peers accounted for just less than 50% of social interactions of school-aged children, yet the influence these interactions have on children is startling.

Greenwood (1981) stated that in studies that investigated the controlling properties of peer groups over group members, a trend could be identified in which groups tend to provide social consequences for behaviors largely
opposed to those desired by adults. Buehler, Patterson, and Furniss (1966) conducted an observational study of delinquents and found peers were effective in programming for the acquisition and maintenance of deviant behavior of children in the group. A study of students in a sixth-grade classroom (Solomon & Wahler, 1973), found peers attended almost exclusively to deviant behaviors of problem children and ignored their prosocial behaviors. When peers were taught to provide reinforcement for appropriate classroom behavior, the performance of the target student improved.

Second, under certain conditions, peers have been shown to be at least as effective as teacher-led instruction, in teaching skills to each other (Gerber & Kauffman, 1981). One-to-one instruction implemented by peers can increase students' opportunities to respond to instructional materials, to be engaged actively in the instruction, and to receive immediate feedback for responses (Delquadri, Greenwood, Whorton, Carta, & Hall, 1986). Use of peers allows for intensive one-to-one instruction that can be individualized to meet the needs of each student, without requiring the majority of students to be engaged in independent seatwork. Consequently, peer interventions reduce behavior problems and increase the amount of time the teacher has available for monitoring students and troubleshooting problems.

There are benefits to students who serve as tutors, as well as to the students who receive tutoring help. Benefits to tutors have ranged from academic gains (Chiang, Thorpe, & Darch, 1980) to improved on-task behavior in other classroom settings (Polirstok & Greer, 1986). Jenkins and Jenkins (1981) stated that aside from academic benefits of tutoring, tutors also improved in attitude toward school, racial relations, and self concept. Students
involved in changing the behavior of peers have taken ownership of learning, become more responsible for completing assignments, and have better controlled their own behavior (Harris & Aldridge, 1983; Miller, 1984).

Peer interventions can be used as methods for effectively including and increasing the chances for success of students with disabilities in mainstream activities (Brown, 1986; Heron, Heward, Cooke, & Hill, 1983; Madden & Slavin, 1983). The use of peer interventions can increase the number of opportunities for disabled learners and regular students to be involved with one another. Opportunities to become actively involved with students with disabilities have increased their social acceptance and social interactions with regular peers (Guralnick & Groom, 1988; Haring, Breen, Pitts-Conway, Lee, & Gaylord-Ross, 1987).

Peers may be better able to observe and consequence behaviors of a target student (Carden-Smith & Fowler, 1984). The teacher may not be able to observe the student's behavior at all times due to other distractions, tasks, or lack of proximity. Peers are more often in the same circumstances and in closer proximity to the target student than the teacher. Peers can deliver a consequence for behavior at all times of the day, including times when the students are in other classes, at play, or when the teacher is busy with other tasks.

Involving peers in behavioral programs can also avoid stimulus control problems that may arise with having one or only a few individuals that administer contingencies (Cooper et al., 1987). The student may perform the behavior only during those times when the person administering the contingencies is present. This discriminative stimulus is a cue to the student
that the contingencies are "on." By using peers as behavior change agents, the desired student behavior may be performed across a wider variety of settings and situations (Anderson-Inman, Walker, & Purcell, 1984; Goldstein & Wickstrom, 1986). Involving peers as intervention change agents may help to contribute to generality of the target behaviors, although not reliably so (Walker, Hops, & Greenwood, 1981).

In order to individualize instruction and to ensure that students engage in productive academic time maximally, the teacher must rely on available resources. One such source is the children themselves. Several methods are available that use students as change agents which can enhance individualization of instruction and capitalize on the skills and knowledge of children. Two methods that have been widely researched and implemented are peer and cross-age tutoring and cooperative learning groups.

Because of the recent emphasis on achievement and proficiency testing (National Commission on Excellence in Education, 1983), teachers have become more aware of the need to use effective instructional techniques and to utilize the resources available to the greatest possible extent. One-to-one instruction has been shown to produce significantly higher achievement than whole-group instruction (Bloom, 1984).

Tutoring refers to the practice of giving additional, special, or remedial instructional help to a student, usually on an individual basis. The term tutoring may refer to large-scale programmatic efforts or to one-time, limited instructional strategies (Gerber & Kauffman, 1981). Using students as instructional tutors is one way to increase the amount of one-to-one instruction available to students,
without imposing a constant demand on the teacher's time (Reisberg & Wolf, 1986).

Students tutoring other students is not a new educational strategy, dating back to the first century AD (Krouse, Gerber, & Kauffman, 1981), but it has recently regained the attention of educators and researchers. Formalized tutoring systems were developed in the late 1700s by Andrew Bell and Joseph Lancaster (Goodlad & Hirst, 1989). During the 1960s, an imminent shortage of teachers, reform demanding innovation, and time- and cost-effective means of individualizing instruction renewed interest in tutoring programs (Gerber & Kauffman, 1981). In the 1970s, legislation mandated that students with special needs be given a free and appropriate education, and included provisions for a plan detailing that individualized educational program, and in the 1980s and 1990s, budgetary reductions and a reform movement toward increasing student proficiency, have again renewed general interest in peer tutoring. Although there is a long history of using peers as tutors, there has been a recent renewed interest and popularity in this practice (Field, 1981).

Teachers have almost always arranged peer tutoring in simple dyads, with one person acting as the teacher and one person receiving the instruction. Most tutoring instances occur on an informal basis between two students assigned to work together because one is having difficulty on a certain skill or task, the other student is proficient and is expected to teach the skill. Because of the informal nature of many programs, data are not collected, programs go unrecognized, and records of effectiveness go unreported. But, different situations and expected outcomes require different types of tutoring and varied amounts of structure.
Tutoring takes place under many different conditions and for various reasons. Tutors can be approximately the same age as the student receiving instruction, peer tutoring, or differ in age by two or more years, cross-age tutoring. Peer and cross-age tutors usually come from the same school or school district as the students they tutor. Most often tutors volunteer their time and services and receive little, if any, formal training and recognition. Tutoring has moved from these informal instances toward more formal, structured programs.

Students have effectively implemented many different tutoring strategies (Gerber & Kauffman, 1981) in many subject areas (Greenwood, Carta, & Hall, 1988). As tutoring programs are implemented across different environments and student populations, the need has increased for experimental demonstrations of effectiveness of formal procedures and different formats. While incidental and spontaneous tutoring do occur within informal peer interactions (Hamblin, Hathaway, & Wodarski, 1974; McCarty, Griffin, Apolloni, & Shores, 1977), the focus here will be on systematic academic tutoring programs that use students as direct peer teachers or occur in the home with parents as tutors.

TUTORING: FORMATS AND PROCEDURES

A literature review was conducted to examine experimental research studies on tutoring systems that have included formal procedures, training, and/or evaluation, and have used school-aged children as academic tutors. The studies presented were published in educational and special education journals between 1980 and 1991 and were chosen as representative examples of the range and scope of different tutoring formats and program procedures,
subjects, dependent variables and results, and other effects (cf. Miller & Heron, 1991).

Tutoring formats have been developed that differ in regards to the relationship of the tutor to the tutee and/or the setting in which tutoring takes place. The main orientation is pull out programs that provide 1-to-1 tutoring for only selected students and take place in an environment other than the classroom. These pull out programs often take place in the classroom, with a small group of tutors and tutees participating in 1-to-1 tutoring dyads, while other children work independently or with the teacher, on a different assignment. Tutoring can also take place on a classwide basis, either with students participating as dyads, or with the dyads forming competitive teams. Each tutoring format has specific training and monitoring considerations, and certain advantages (Miller & Heron, 1991). The most widely used formats are classwide peer tutoring systems, cross-age tutoring, one-to-one tutoring, and home-based tutoring. Each format will be discussed as to the general procedure and organization, advantages and disadvantages, and a review of effectiveness data.

**Classwide Peer Tutoring Systems**

Classwide peer tutoring systems (CWPT) are those in which all students participate at the same time in tutor-tutee pairs working together on a classwide basis (Carta, Greenwood, Dinwiddie, Kohler, & Delquadri, cited in Greenwood, 1991). The goals of this tutoring format are to improve basic skills performance of low-achieving minority, disadvantaged, or students with mild disabilities within the regular classroom setting (Delquadri et al., 1986) and to increase the number opportunities each child has to respond actively to academic materials.
(Greenwood, 1991). The program format is applied to academic content determined by the teacher from the materials available and the curriculum of study of the school district. Individualization can take place for each student within the pairings.

In CWPT, students within the classroom are trained to be tutors for other students in the class. Students in a CWPT program can be trained to participate in the program only as a tutor (e.g., Heward, Heron, Ellis, & Cooke, 1986; Kamps, Locke, Delquadri, & Hall, 1989), or may be trained to take the role of both student and tutor in a reciprocal peer tutoring system (e.g., Cooke, Heron, & Heward, 1983; Greenwood et al., 1987; Pigott, Fantuzzo, & Clement, 1986).

In the reciprocal peer tutoring arrangement, children not only help each other learn, but also learn by teaching (Goodlad & Hirst, 1989). The teacher monitors pairs by moving throughout the classroom to provide assistance and praise desired tutoring behaviors.

Students are paired for tutoring by the teacher. Pairing of reciprocal tutors can occur on a random basis (Kohler & Greenwood, 1990), in rank order to assure similar skill levels, or with special considerations for students with behavior or achievement problems (Cooke et al., 1983). Within the pairs, students take turns administering instruction, each taking about 10 minutes practice as a tutor. Typically, tutoring sessions last 30 minutes, with the remaining time spent in testing, review, or clean up. During instruction, the tutee may be required to respond orally or in writing. As the tutee responds to the materials presented, the tutor provides feedback, models error correction, and praises correct responses. Since the tutors are of the same age and
approximate skill level of the tutees, classwide programs require intensive training of students as tutors.

Tutor training in CWPT procedures usually includes instructional practice procedures, rules for behavior during the sessions, stimulus card presentation (sight word, math fact), reinforcement of correct responses, error correction procedures, how to gain attention of the teacher, and record keeping. Programs have also included training in handling of behavior problems (Kamps et al., 1989), "Tutor Huddle" an additional practice segment for tutor acquisition of materials (Heron et al., 1983), daily testing (Heward et al., 1986), folder maintenance (Greenfield & McNeil, 1987), and praising on a specific intermittent schedule (Heward et al., 1986). Training for CWPT ranges from sessions lasting from a total of 30 minutes (Delquadri, Greenwood, Stretton, & Hall, 1983) to training until mastery (Franca, Kerr, Reitz, & Lambert, 1990). The average length of training for CWPT is about 5 sessions lasting 30-45 minutes each.

Some CWPT programs have included group-oriented contingencies as an additional feature (Delquadri et al., 1983, 1986; Greenwood et al., 1987; Maheady & Harper, 1987; Pigott et al., 1986). These CWPT programs can be classified as cooperative learning models, and in fact, often have more detailed and involved procedures than most cooperative learning models. The addition of group-oriented contingencies facilitates some forms of social cooperation among group members (Greenwood & Hops, 1981). This additional outcome is desirable and may be especially beneficial in mainstreaming students with disabilities into regular classrooms.
When using CWPT with group-oriented contingencies, the class is divided into two competing teams. Students earn points for responding correctly, making corrections to errors, and responding to test items correctly. Bonus points may be awarded by the teacher for responding immediately to the tutor, cooperative working, and/or appropriate behavior. Individual points are summed and reported to the teacher at the end of each tutoring period. Points are posted on a large chart and team totals are calculated each Friday. The winning team is applauded for winning, and the losing team for trying.

The CWPT format has been found to be effective in increasing student achievement when used to teach spelling (Delquadri et al., 1983; Greenwood et al., 1987; Kohler & Greenwood, 1990; Maheady & Harper, 1987; Mallette, Harper, Maheady, & Dempsey, 1991), reading and language (Cooke et al., 1983; Greenwood, 1991; Greenwood et al., 1984; Kamps et al., 1989), vocabulary (Heron et al., 1983), math (Cooke et al., 1983; Franca et al., 1990; Greenfield & McNeil, 1987; Greenwood, 1991; Pigott et al., 1986), writing (Stanley & Greenwood, cited in Delquadri et al., 1986), and social studies (Maheady, Harper, & Sacca, 1988; Maheady, Sacca, & Harper, 1988). CWPT leads itself most readily to factual information, but has been used to teach higher level skills, such as oral reading, writing, and reading comprehension.

One advantage of using a CWPT system is that all students in the class are engaged actively with the academic materials for about 20 minutes. Time spent engaged with the materials include that as a tutee and as a tutor. This double exposure to the materials greatly increases the number of opportunities the student has to respond (Delquadri et al., 1986) and the amount of time academic engagement (Greenwood, 1991). Another advantage is that CWPT
has been shown to be effective in increasing measures of curriculum-based achievement (Greenwood, Delquadri, & Hall, 1984; Maheady & Harper, 1987) and grades (Maheady, Sacca, & Harper, 1988). The flexibility of the program is another advantage: teachers can use CWPT to teach skills and materials they select; CWPT can be used across a wide range of subject areas, student ability and age levels; and since tutors are members of the class, tutoring can be implemented at a time that best fits the class or teacher's schedule. Finally, students, teachers, and parents like the program (Greenwood et al., 1987).

The disadvantages of CWPT include teacher time expended planning and preparing to use the program, the amount of time required to train students as tutors, and the coordination of large amounts of materials and information produced by the program. Teachers need to implement a good system for record keeping, reviewing, and providing new information to students.

**Cross-Aged Tutoring**

Cross-age tutoring can be an effective method of providing individualized instruction (Schrader & Valus, 1990). Cross-age tutoring refers to tutoring situations in which the tutor is a student approximately two or more years older or younger than the student receiving tutoring. Cross-age tutors are often used when the teacher believes the students are too young to teach each other. This method is based on the assumptions that an older tutor can provide an appropriate role model for the younger tutee, the older student can benefit from the tutoring experience, and the older child can effectively teach skills that require individualized instruction for which the teacher does not have enough time (Johnson & Bailey, 1974).
The age difference usually serves to delineate the tutor/tutee roles. There need not be large differences in skill levels between the tutor and tutee, as it has been shown that both members of the tutoring dyad benefit from the experience (Brown, Rollins, & McCandless, 1988; Polirstok & Greer, 1986). Cross-age tutors can come from different sources. Most cross-age tutors come from other classes of older children within the same school building. In some rare cases, junior high or high school students from campuses with close proximity to the elementary school have been used (Barbetta, Miller, Peters, Heron, & Cochran, 1991).

Using cross-age tutors requires careful scheduling. Teachers with students involved in the program must work together to arrange and set a suitable tutoring time. Students selected to be tutors sometimes miss classroom instructional time, but these students are not usually adversely affected by the "lost" instructional time (Chiang et al., 1980). The need for a set tutoring schedule, and dependence on help from outside the classroom, makes cross-age tutoring a less flexible resource than other tutoring formats.

Materials for cross-age tutoring and skills to be taught are usually determined by the teacher of the child receiving tutoring. Junior high and high school tutors have also selected skill areas to be taught, planned, and/or developed materials for use in tutoring (Barbetta et al., 1991; Haisley, Tell, & Andrews, 1981; Maher, 1984).

Sessions to train cross-age tutors usually lasted from 45-minutes (Barbetta et al., 1991) to 5 hours (Folio & Norman, 1981). Most programs included instruction on specific tutoring procedures or activities, error correction, social and positive reinforcement, and behavior management techniques. One
cross-age tutoring program (Vacc & Cannon, 1991) required tutors to complete 30 hours of training due to the severity of the disability conditions of the tutees. Tutor training included learning of sign language, behavior management techniques, and problem solving skills, above and beyond the usually taught tutoring procedures. A second study (Haisley et al., 1981) also required eighth- and ninth-grade students to undergo intensive tutor training, including 6 weeks of informal observations and training in a resource center, and twenty 45-minute sessions on direct instruction, task analysis, communication, behavior management, instructional design, and classroom survival skills.

An advantage of using cross-age tutors is the skill and experience tutors can bring to the tutoring program. Although this has typically meant that tutors require less training, now cross-age tutors are used in a greater variety of situations. Programs serving students with more severe disabilities and the selection of tutors with disabilities require intensive training sessions to be planned. A disadvantage of cross-age tutoring is the lack of flexibility due to the coordination of schedules.

One-to-One Tutoring

Most tutoring experiments, as well as informal tutoring incidences in schools, have been conducted on a small number of students, tutoring in one-to-one situations. Only select students participate in programs designed with this format, usually students needing remedial help with classroom content or social behaviors, and this method differs procedurally from cross-age tutoring only in the identification of tutors.

Training sessions for one-to-one tutoring differ depending on the abilities of the tutors and tutees, and the tutoring procedures. One-to-one tutoring
programs ranged from no formal training (Campbell, Scaturro, & Lickson, 1983) to two 30-minute sessions per weeks for 8 weeks (Osguthorpe, Eiserman, & Shisler, 1985). Sessions to train tutors have included instruction on specific tutoring procedures, error correction, questioning techniques, communication skills, and often times behavior management techniques. In some programs, tutors received weekly training or instruction (Eiserman, 1988; Osguthorpe et al., 1985), played an board game to facilitate discussion and education (Campbell et al., 1983), or held booster sessions as needed (Shafer, Egel & Neef, 1984).

**Home-Based Tutoring**

Parents are the child's first teachers and remain a powerful source of influence throughout the life of the child. Most parents are willing to help with homework and become concerned when their child is experiencing difficulty in school, but have not been formally used by schools to affect academic changes. Home-based tutoring programs have not been widely studied, as monitoring and data collection are difficult, parents already help children informally, and generality from home to school is questionable and hard to determine.

Parents can serve as tutors for their children (Barbetta & Heron, 1991). Since parents are the child's first teacher, continuing to teach and help the child is a natural extension. Although teachers sometimes wish parents would become more involved in the education of their child, the use of parents as home-based instructional change agents has been greatly overlooked by educators (Thurston & Dasta, 1990). Parents can be trained to be co-teachers of their children and to affect changes at home that support learning at school (Elksnin & Elksnin, 1991).
Training of parent-tutors can take place in the home, at school, or in a clinical setting. Training sessions should include instruction in tutoring procedures, error correction, reinforcement techniques, testing, recording of progress. It is important for parents to understand that tutoring should and can be short in duration, a positive experience for both parent and child, and still affect academic changes. In order to achieve these goals, parents need to be trained to implement tutoring procedures based in behavioral principles (Elksnin & Elksnin, 1991).

Experimental research studies have been conducted and have found that home-based summer tutoring increased academic skills (Barbetta & Heron, 1991), parent tutor training increased the academic behavior of the child at home and at school and increased parent tutoring behaviors (Thurston & Dasta, 1990), and home-based reinforcement given contingent on points earned for peer tutoring behaviors recorded at school was associated with a larger increase in reading achievement than tutoring without home-based reinforcement (Trovato & Bucher, 1980).

Students Selected for Tutoring Research

Students involved in tutoring programs have traditionally been selected based on a remedial model (Heron & Harris, 1987). Traditionally, students have not been referred or selected for tutoring unless the child lacked a desired skill. Students selected to serve as tutors were chosen by experimenters for several different reasons. Traditionally, tutors have been used in special education classes and have been older, more skilled students who came from regular classrooms (Fimian, Fafard, & Howell, 1984). Recently, research studies have moved away from this traditional pairing and described or
investigated same-aged tutors and students with disabilities as tutors. Both tutors and tutees have been shown to benefit from tutoring programs.

**Tutees.** Students who have received tutoring services through peer tutoring methods have included tutees in grades K-12. Recent tutoring programs have included groups of children selected based on the available benefits for tutees, rather than skill deficits, those not represented in the repertoire of the students.

Classwide tutoring has been used with students in grades K-12. Subjects with special needs have include inner-city students, students with leaning disabilities, behavior disorders, autism, mental retardation, and hearing impairment (Delquadri et al., 1986). Greenwood et al. (1984) reported that the procedure was also implemented with non-English speaking students with limited success.

Cross-age tutoring has been used to teach students in grades K-12. Tutees have included students in regular classrooms, students with reading or word recognition difficulties (Barbetta et al., 1991; Polirstok & Greer, 1986; Sindelar, 1982), learning disabilities (Chiang et al., 1980; Lazerson, Foster, Brown, & Hummel, 1988; Scruggs & Osguthorpe, 1986), students with moderate disabilities (Vacc & Cannon, 1991), mainstreamed exceptional students (Folio & Norman, 1981; Haisley et al., 1981), students with mental retardation (Brown et al., 1988; Maher, 1984), and incarcerated youth with learning disabilities (Kane & Alley, 1980).

The published research classified under one-to-one peer tutoring most often refers to the use of general education peers as tutors (cf. Campbell et al., 1983; Lancioni, 1982; Russell & Ford, 1983; Young, Hecimovic, & Salzberg,
but recent experiments have included students with disabilities as peer tutors (McKenzie & Budd, 1981; Osguthorpe et al., 1985; Osguthorpe & Scruggs, 1986; Roach, Paolucci-Whitcomb, Meyers, & Duncan, 1983; Shafer et al., 1984).

Home-based tutoring programs have targeted students identified as needing assistance with academic skills (Barbeta & Heron, 1991), children of interested volunteers (Thurston & Dasta, 1990), students failing math or spelling (Thurston & Dasta, 1990), and students deficient in reading skill areas (Trovato & Bucher, 1980).

Tutors. Tutors used in tutoring studies have included students in grades K-12. Recent studies have investigated the efficacy of students with disabilities tutoring regular class age mates (Brown, 1986; Osguthorpe, 1984; Osguthorpe et al., 1985), younger students with disabilities (Koury & Browder, 1986; Lazerson et al., 1988; Maher, 1984), other students with disabilities in a one-to-one reciprocal program (Scruggs & Osguthorpe, 1986), and both normal and peers with disabilities in a classwide tutoring systems (Cooke, Heron, Heward, & Test, 1982; Delquadri et al., 1983; Franca et al., 1990; Maheady, Sacca, & Harper, 1988).

Tutors have included students with mild or moderate mental retardation (Koury & Browder, 1986; Maheady, Harper, & Sacca, 1988; Osguthorpe et al., 1985), and learning disabilities (Eiserman, 1988; Lazerson et al., 1988; Scruggs & Osguthorpe, 1986). Also tutors have been selected from underachieving minority students (Brown et al., 1988), incarcerated youth (Kane & Alley, 1980), students with learning disabled who are truant (Lazerson et al., 1988), poor or low achievers (Greenfield & McNeil, 1987; Pigott et al., 1986;
Polirstok & Greer, 1986), and students with emotional disturbances (Franca et al., 1990; Maher, 1984). Parent tutors were selected based on a volunteer basis (Thurston & Dasta, 1990) or the need of their child for assistance in academics (Barbetta & Heron, 1991; Trovato & Bucher, 1980).

Tutor selection has changed to reflect changing needs of both tutors and tutees, and the changing goals of tutoring programs. Improved training methods, tutoring procedures, and materials have resulted in the inclusion of tutors who would not have been utilized in earlier tutoring programs. Tutor training often includes acquisition of academic and social skills that were formerly expected of students selected as tutors.

**Tutoring Outcomes**

Tutoring procedures have often been implemented to increase tutee achievement in academic areas in which deficits were noted, with minimal cost in terms of teacher time (Gartner, Kohler, & Reisman, 1971). Interest in academic outcomes for students with disabilities has been joined with measurements of tutor behaviors, social interactions, and collateral effects. The dependent variables being measured in the experimental research have changed to measure student attitudes, procedural reliability, and tutor behaviors.

Research of structured tutoring programs using children as tutors has been on the increase (Devin-Sheehan, Feldman, & Allen, 1976). Structured peer tutoring programs have been shown to affect tutees positively through measured improvement in achievement of academic skills (Brown et al., 1988; Chiang et al., 1980; Delquadri et al., 1983; Greenwood et al., 1987; Jenkins & Jenkins, 1981; Maheady & Harper, 1987; Maheady, Harper, & Sacca, 1988),
attending and on-task behavior (Haisley et al., 1981; Kamps et al., 1989), increased academic engaged time of students with low socioeconomic status (Greenwood, 1991), and number of learning trials (Heron et al., 1983).

Studies measuring tutor behaviors have been examined and have shown positive increases in correct implementation of tutoring procedures (Greenwood et al., 1987), record keeping (Haisley et al., 1981), use of behavioral terminology (Campbell et al., 1983), percentage of correct responses praised (Heward et al., 1986), and academic achievement (Chiang et al., 1980; Delquadri et al., 1983).

Academic behaviors and skills have been the focus of this literature review, however, attitudes, social skills, and interactions were also measured in many studies. Measures of tutee behaviors and/or attitudes demonstrated that participation in tutoring resulted in an increase in social skills, attitudes, and social interactions (Franca et al., 1990; Goldstein & Wickstrom, 1986; Lancioni, 1982; Maheady & Sainato, 1985), and reduced disruptive behaviors (Folio & Norman, 1981). Measurements of tutor behaviors and/or attitudes showed participation in tutoring increased the expectations tutors had for students with disabilities (Folio & Norman, 1981), and resulted in increased social interactions with teachers (Campbell et al., 1983).

Eiserman (1988) found that social acceptance of students with learning disabilities by regular students increased under one-to-one and reciprocal peer tutoring interventions. At the same time, the students with learning disabilities, especially those who participated as reciprocal tutors with regular students, scored lower on posttest than they did on pretest scores on measures of attitudes toward school. Contrary to other studies, Lazerson et al. (1988) found
an increase in the self-concept of the tutors. This result was possibly due to the
different social measurement instruments used.

Other effects. Increasingly, collateral behavior changes during certain
aspects of tutoring programs have been examined. The analysis of
components functionally related to these changes has been carefully controlled
to determine which variables are necessary and sufficient to produce the
changes. Decreased truancy was noted as a result when truant junior high
school students participated in a cross-age tutoring program (Lazerson et al.,
found that appropriate academic and social performance and on-task behavior
of tutors increased in non-tutoring settings when tutors were trained and
awarded tokens to use social reinforcement during tutoring.

Methodological Procedures

Choosing a tutoring program to meet the needs of the students and the
goals of the teacher is important. Once the format for the tutoring program has
been decided, the specific method to be used and the way in which the program
will be implemented must be decided. In light of this decision, a review of the
methodology that produced positive effects will follow. Methodology that has
been implemented to produce positive outcomes in training, correction
procedures, outcomes and evaluation will be discussed.

Training procedures. The procedures used to train tutors have varied
along a continuum from completely unstructured to highly structured (Krouse et
al., 1981). Tutors who have received specific training in the procedures of the
program have been found to emit more appropriate tutoring behaviors than
those tutors who where untrained (Greenwood et al., 1988; Parson & Heward,
Tutor training procedures are generally based on a task analysis of the tutoring role, with the steps systematically trained in sequence or in order of importance. The extent and type of training implemented relates directly to the goals and the complexity of the tutoring task and the skill of the tutor.

The recent focus of tutoring programs using children as tutors has been away from simple effectiveness demonstrations and toward training students with disabilities as tutors and tutoring as a way to increase social integration of students with disabilities into the mainstream. Because these tutoring systems are more complex, tutor training is an essential part of the program and must be more structured. Teachers should prepare tutors by providing and training them to use a clear instructional routine. In most of the systematic tutoring programs examined, the routine included a mechanism for presentation of the instruction, numerous opportunities for the tutee to respond, feedback, error correction, and reinforcement. Some tutoring programs included tutor recorded data.

Training can take place in a large group, small group, or on an individual basis. Training in a small group is ideal for providing students with more practice and feedback. Training students individually allows for individualization of specific skills or information that the tutor may be lacking, but demands an enormous amount of time. Training in a large group is useful when the teacher has no outside help or if CWPT will be used.

The model, lead, and test instruction sequence outlined by Carnine and Silbert (1979) was used effectively to train peer tutors, even at a very young age (Cooke et al., 1983; Parson & Heward, 1978). This model was used to train tutors in several tutoring programs (Barbetta & Heron, 1991; Barbetta et al., 1991; Delquadri et al., 1983; Heron et al., 1983; Jenkins & Jenkins, 1981;
The structure of this model produced active students, provided practice to develop new skills, allowed students to receive feedback on performance, and provided the teacher with a method for evaluation of the training. Scripted lessons have also been used with this model (e.g., Barbetta et al., 1991; Heron et al., 1983) to keep training consistent across groups and to cue the behavior of the trainer.

When students with disabilities serve as tutors, training often becomes more involved. Maher (1984) trained adolescents with disabilities to be cross-age tutors for younger students with disabilities. Extensive tutor training included not only tutoring procedures and skills, but also provided information on the disability conditions of the tutees, academic areas that could be tutored, and prerequisite academic skills. Maher used activities during tutor training consisting of didactic presentations by the trainer, individualized meetings between tutor and trainer, group discussions, role-playing, and simulations.

**Correction procedures.** Feedback procedures provide information to the learner about his or her performance. Van Houten (1980) suggested that in order to be effective, feedback must be precise, immediate, frequent, positive, and differential. Providing the student with this kind of information about his or her performance increases the chances that learning will take place at an optimal rate and emphasizes improvement. Tutoring procedures that incorporate feedback procedures often require more training of the tutor, but are also more effective.

Corrective feedback can give general or specific information to the student about the error (Grimes, 1981). General corrective feedback gives information which tells the learner that an error has been made and the student
tries an alternative response, using a trial and error approach. Specific corrective feedback gives the learner information that an error has occurred and then gives information, or a prompt, on how to correct the mistake.

Tutors have been taught to prompt and praise correct answers by the tutee. Praise and tokens awarded by tutors in programs contingent upon the tutee emitting correct responses or appropriate behavior, have been found to related to higher academic achievement and student attitudes than students not receiving tokens or receiving them non-contingently (Brown et al., 1988). Many studies have included contingent reinforcement, either token or social reinforcement, in daily tutoring procedures (cf. Delquadri et al., 1983; Greenwood et al., 1987; Heron et al., 1983; Maheady & Sainato, 1985; Maher, 1984).

An advantage of tutoring procedures is the immediacy of the feedback given to the student after a response is made. A disadvantage of peer tutoring using students of the same skill level, or learners with disabilities, is that the tutor may have trouble identifying the correct answer. This problem can be avoided by encoding the correct answer for the tutor in some way, perhaps on the back of the flash card used to present the information. Prompt cards can display words and/or picture cues for the tutor (Osguthorpe et al., 1985).

In tutoring sight words, a correct pronunciation model is difficult to provide. Heward, Heron, and Cooke (1982) implemented a procedure designed to introduce new words to the tutors, before they presented the new words to their tutees. The "Tutor Huddle" procedure divided tutors into heterogeneous groups of students to review the material they would be presenting that day during tutoring. The members of the tutor huddle took turns
reading the words that would later be presented to their tutees, as other members of the huddle confirmed or corrected the responses.

Error correction procedures have differed widely across tutoring programs. Foxx and Jones (1978) described a positive practice technique in which students were pretested, those items on which errors occurred were determined, and positive practice followed a day later. A time delay of 24 hours reduces feedback to the learner and increases the amount of time required to complete the learning trial, and therefore the amount of time required to learn the correct response. Peer tutoring studies have used immediate positive error correction procedures (Barbetta et al., 1991; Delquadri et al., 1983; Heron et al., 1983). In some tutoring programs, tutors indicate that the response is incorrect (i.e., "Wrong", "No") and then give a prompt, cue, or the correct response (Koury & Browder, 1986; Maheady & Harper, 1987; Young et al., 1983). Although relatively few research studies have been conducted in the area of error correction procedures, common practice indicates that teachers should use positive corrective feedback, parsimoniously correct the error, and end with the tutee making a correct response.

Koury and Browder (1986) found that students with moderate disabilities were able to use a constant time delay procedure in word presentation to quickly and efficiently fade prompts and decrease time required for mastery. The use of time delay procedures resulted in rapid acquisition of words by all tutees.

Other outcomes. Outcomes of tutoring programs must be analyzed carefully. Many experimental studies on tutoring have included demonstrations or comparisons of tutoring packages or procedures against other packages.
Those variables within the tutoring package contributing to the success and control of the program have not always been carefully examined. Some components have been examined individually and functional relationships have been shown in several cases.

Training, with tokens administered to tutors for use social reinforcement during tutoring, has been shown to increase the number of appropriate academic and social performances and percentage of intervals on-task of the tutors in non-tutoring settings (Polirstok & Greer, 1986). Brown et al. (1988) found that tutees receiving praise contingent on desired academic behaviors made significantly larger increases in specific reading behaviors than students who received praise non-contingently at the end of the tutoring session. These are significant findings, showing the importance of measurement of behaviors related to tutoring in different settings.

**Monitoring and Evaluation**

Once a tutoring program is implemented, it is important to monitor and evaluate the performances of both tutor and tutee (Krouse et al., 1981). Monitoring must be conducted throughout the program so that modifications can be made when necessary, and positive reinforcement can be delivered appropriately. Monitoring can be done by the teacher or a student. Accuracy of procedures, academic progress, maintenance, generality, and social validity are areas in which monitoring can and should take place.

**Procedures.** When students are utilized as academic intervention agents, teachers must be sure that procedures are being appropriately applied and followed. Since the teacher is still accountable for student learning, records of procedure implementation should be kept. Measurement of
procedural reliability have been implemented to ensure students are being taught accurately and with efficacy. Studies measuring tutor behaviors have examined have and shown students are able to correctly implement tutoring procedures (Greenwood et al., 1987), use behavioral terminology (Campbell et al., 1983), and praise correct responses on an intermittent schedule (Heward et al., 1986).

Teachers can enhance the procedural reliability of tutors in the tutoring program by attending to and reinforcing desired tutoring behaviors. Supervision of the tutor-tutee pairs should include quality checks on accuracy of procedures, academic responses and prompts, record keeping, and positive social interactions. Cheating occurs rarely in a system with teacher checks for accuracy.

**Acquisition.** Monitoring and evaluation of student skill acquisition is an important part of all teaching. Progress can only be measured with respect to past performance. Daily and weekly progress data can be incorporated into the daily tutoring procedures of the program (Heron et al, 1983: Jenkins & Jenkins, 1981). Charts and graphs are efficient ways to gather and display data. Tutors can be trained to record tutee acquisition of skills on simple bar graphs by coloring in a box for each word mastered (Heron et al., 1983), by awarding and recording points for correct answers (Delquadri et al., 1983, 1986; Greenwood et al., 1984). Other evaluation techniques include standardized testing (Greenwood et al., 1984), observations, and analysis of permanent student products (Greenfield & McNeil, 1987; Pigott et al., 1986).

**Maintenance.** Probes of academic outcomes have been measured across time following the termination of the intervention. Heron et al. (1983)
reported that students not only learned words in the peer tutoring program, but also the words were retained for up to five months. Maintenance of behavior gives the teacher more information and a way to evaluate the effects of the tutoring program. Maintenance procedures in this study were built into the weekly tutoring routine, with previously mastered word sets being placed in the folder for review. Words that were not retained were retaught.

**Generality.** Generality of behavior is difficult and evasive. Maintenance and generality of student behavior after the behavior change project is finished is desired goal of behavior change programs. Rather than expect behaviors and skills to generalize across behaviors, settings, or students, teachers must plan for generalization (Stokes & Baer, 1977). Using different peers as change agents, altering the unimportant parts of the stimulus to make the student attend to only the salient features, and training of stimuli likely to be in the generality setting may help to promote generalization. The training of generality is also an important goal in measuring the social validity of the tutoring program.

**Social validity.** The satisfaction of the participants is an important factor in the implementation of a behavior change program. Social validity is monitored and measured to insure the technique is acceptable to the participants and is a procedure that is likely to implemented after the experiment is completed. Social validity can be measured by using questionnaires, surveys (Maheady, Harper, & Sacca, 1988) conducting interviews (Barbetta & Heron, 1991; Maheady, Harper, & Sacca, 1988), and rating scales (Brown et al., 1988). Many studies report that the participants enjoyed the program, but an excellent measure of satisfaction is the maintenance of the program after the experiment is completed.
In order to maintain the tutoring program after the experimenter leaves, the change agents (peers, as well as teachers) involved in bringing about the desired behavior change may also need to have contingencies maintaining their behavior. An analysis of the contingencies effecting teacher behavior and the addition of "built in" contingencies for program maintenance from the outset of the program may increase the utility and maintenance of the program (D. P. Wacker, personal communication, September 26, 1991). The teacher will need to be reinforced for continuing to implement the peer tutoring program, the students involved in cooperative learning will need to be reinforced to maintain their cooperative behaviors. Intermittent reinforcement and indiscriminable contingencies can be programmed to maintain both the behavior of the learner and the behavior change agent. Building in rewards and reinforcement to the usual requirements of the setting are one solution. Maintaining behavior through the naturally occurring contingencies of reinforcement is ideal.

**Component Analysis**

The effectiveness of peer tutoring methods have been demonstrated and replicated across the literature. There are many ways in which the teacher can arrange the environment or activities to result in student learning and increased social interactions. These methods are implemented as treatment packages that have been shown to effectively increase student academic achievement and social interactions between students. Multiple experiments have been conducted to investigate the effects of different combinations or arrangements of the components involved in producing the desired changes.

The experimental literature in peer tutoring has demonstrated a fairly detailed analysis of the functional relations of the variables contributing to the
effectiveness of the treatment. Peer tutoring procedures have been shown to increase the number of opportunities for the student to respond to academic materials (Heron et al., 1983; Greenwood et al., 1984), increase the amount of time students spend engaged in academics (Greenwood, 1991), reduce truancy and tardiness in students participating in the program as tutors (Lazerson et al., 1988), and increase academic achievement across a variety of subject areas (Delquadri et al., 1986). Additionally, an increase in tutor on-task behavior in non-tutoring settings has been functionally related to training in contingent approval of tutee behaviors (Polirstok & Greer, 1986).

Implications for Classroom Teachers

Implications for the use of tutoring by practitioners fall along several lines. Teachers should be encouraged to use tutoring in their classroom, share the technology with other teachers in their school or school district, and to involve parents of their students to implement tutoring procedures at home.

Tutoring in the classroom. Tutoring has been shown to be effective to increase time students spend actively engaged with the curriculum and academic achievement. Tutoring programs provide students with more opportunities to respond actively to academic materials. Because students are actively engaged, behavior problems are reduced, giving the teacher more time to monitor academic behaviors.

Tutoring has been used with students at all ages and has been shown appropriate and beneficial for both tutors and students. Tutoring can be used with a variety of curriculum areas. Although not all areas have been experimentally analyzed, peer tutoring programs have been used to teach almost every subject and skill area. Children like tutoring. Students especially
enjoy being the tutor. If reciprocal tutoring is not possible because of skills levels, try to arrange tutoring on some activity or skill in which lower level students may have the opportunity to tutor. Each child should get a chance to be the tutor.

**Dissemination of tutoring in the schools.** Teachers using tutoring methods in their classroom should be encouraged to invite other teachers, especially regular education teachers to observe, learn, and participate in tutoring procedures. Sharing knowledge will make for better mainstreaming situations and provides opportunities to build professional relationships and knowledge -- you share ideas, I'll share ideas. To cut down on the expense of teacher time, cooperate with a team of teachers to plan, prepare, and implement a tutoring system. Once tutoring is set up, management time takes less time and effort, as most teacher time is expended up front. Team teaching of tutoring can also allow for mainstreaming and social skills development across classes.

**Training parents to tutor.** The teacher can be instrumental in influencing parents to implement a tutoring program at home. Elksnin and Elksnin (1991) reviewed parent training packages based on behavioral principles. Recommendations for implementation of a home-based tutoring program, should include examples of games, procedures, and curriculum areas suitable for home use. Excellent times for sharing ideas for home-based tutoring programs with parents are open house or before summer vacation. Give parents specific instructions for tutoring procedures, praising, error correction, and record keeping. Make the tutoring program short, positive, and fun. Building in reinforcement for the students make the tutoring time fun, and may help parents maintain the program.
Implications for Teacher Educators

It is important for teacher educators to disseminate results of research on teaching. Teacher educators have a strong impact on the methods used by teachers in the field, and the implementation of teaching methods presented. Tutoring should be one of the methods to which pre-service teachers are exposed.

Presenting tutoring methods. Special education teacher educators have been effective in presenting and introducing tutoring to students preparing to become special educators. General educator teacher trainers, on the other hand, need to make students aware of the benefits of tutoring methods. Information about tutoring programs could be important for general educators in the field to better mainstream students and to individualize instruction for "at risk" populations. More information must be given to regular teacher educators at the college level if we are to increase the use of this effective method.

Students need to become actively involved with tutoring procedures. Tutoring could be introduced in class lectures, videotape presentations, role playing, or classroom visits to sites implementing tutoring procedures. Teacher educators could incorporate practice of these methods in college level courses, using tutoring to teach the curriculum, and possibly require students to pilot tutoring programs in school/service settings.

Implications for the Researcher

The primary task of the researcher is to describe, measure, and evaluate the effects of implementing given procedures or methods on certain desired outcomes. Despite an accumulating body of research and many years of experience, several questions concerning the implementation of peers as
behavior change agents in school settings have not yet been answered. The studies published in the area of tutoring have compared and contrasted different teaching methods and have not always answered questions and concerns of which variables are affecting or are functionally related to the resulting change.

**Tutoring methods.** Tutoring research has been intensive over the past 20 years. Although tutoring has been researched widely, many components and procedures still need to be empirically analyzed. Tutoring procedures and training techniques vary widely. Error correction procedures, prompting, and feedback procedures have not been comparatively examined with relation to effectiveness. Extreme ranges in time engaged in training indicates that the controlling variables and necessary behaviors have not been accurately identified. A comparison of tutoring components would be useful in determining the best way to implement tutoring. Tutoring has focused on academic rather than social outcomes. More information on the effectiveness of tutoring to increase social skills, interactions, and relations would be desirable. Standardized measurements of social affects would contribute to the understanding of these important outcomes.

Dissemination of this technology is limited. Many tutoring models have been tightly controlled experiments, and commercially-made and distributed materials are not readily available for practitioners to use "off the shelf" in the schools. Research should focus on the needs of the teachers and children in the schools, integration into the curriculum, and ways to efficiently distribute tutoring programs and materials.
Summary and Conclusions of Tutoring Literature

Tutoring methods have been used informally for many centuries. A review of the literature on tutoring was conducted. An analysis was conducted on tutoring formats and procedures, subjects, dependent variables and results, and other effects.

This teaching strategy was found to provide solutions to classroom instructional problems facing teachers. Many of the procedures for tutoring have been demonstrated to be effective in increasing opportunities to respond, immediate feedback, academic performances, and social interactions. A summary of the methodology used to produce the observed effects was given.

Tutoring procedures have moved from traditional tutoring programs toward new applications, especially with students with disabilities as tutees and tutors. Many of the procedures implemented within peer tutoring packages need to be examined in more detail with respect to the specific components and methodology producing the effects. Even with the large number of demonstrations of tutoring available and several "how to" packages have been published, no systematically organized commercially-distributed program has been formally made available to practitioners.

Peers can be effective and powerful intervention change agents. Effective procedures have been developed and researched using children as the agents for instructional change. Peer tutoring techniques have both been successfully utilized to affect changes in academic and social skills. Although these methods have been used widely in schools, they require further research and development, especially to determine which components contribute to the effectiveness of these interventions.
GENERALITY OF BEHAVIOR CHANGE

In the field of special education, teachers are encouraged to plan for
generality of treatment effects over time, settings, or persons. It is important for
the student to be able to use the academic or social behavior learned in the
classroom in many other areas or settings. The educational instructional setting
is a contrived environment designed for the teaching of important behaviors in a
controlled situation. All behaviors of importance must have generality to the
"real world" environment and the natural contingencies existing outside of the
classroom.

Baer, Wolf, and Risley (1968), in a landmark article in the first volume of
Journal of Applied Behavior Analysis, included generalization of behavior
change as one of the defining characteristics of applied behavior analysis. To
have generalization, a behavior change had to prove durable over time,
appear in a variety of environments, or spread to a variety of related behaviors.
Stokes and Baer (1977) used the term generalization to describe:

The occurrence of relevant behavior under different, nontraining
conditions (i.e., across subjects, settings, people, behaviors, and/or time)
without the scheduling of the same events in those conditions as had
been scheduled in the training conditions. Thus, generalization may be
claimed when no extratraining manipulations are needed for
extratraining changes; or may be claimed when some extra
manipulations are necessary, but their cost or extent is clearly less than
that of the direct intervention. Generalization will not be claimed when
similar events are necessary for similar effects across conditions. (p.
350)
Cooper et al. (1987) used the term generality to minimize confusion among terms. They point out that behaviors taught within a classroom or teaching setting are not usually the natural environment in which the behavior will, or needs to occur. For a behavior change to be effective and worthwhile, it must be retained across time, and be useful in different settings and ways. For generality to occur, strategies for the promotion of generality must be planned, trained, and programmed into the instruction of the behavior.

Generality can occur in several different ways. Stimulus generality occurs "when a target behavior is emitted in the presence of stimulus conditions other than those in which it was directly trained . . . . The setting in which stimulus generality is desired can contain some components of the behavior change program that was implemented in the training environment, but not all of the components. If the complete program is required to produce behavior change in a different environment, then no stimulus generality can be claimed" (Cooper et al., 1987, p. 556).

Response generality is defined as "the extent to which the learner performs a variety of functional responses in addition to the trained response; that is, responses for which no specific contingencies have been applied are altered as a function of the contingencies applied to other responses" (Cooper et al., 1987, p. 558). Response maintenance is the third type of generality. Maintenance of behavior change means that the individual continues to perform the desired behavior after training has terminated.

Generality of behavior can be promoted by the teacher by focusing on the areas of planning and implementing, prior to the treatment. Heron and Harris (1987) detail that in planning, the teacher needs to focus on "what
behavior will be changed, where the behaviors will occur, and what will be required of individuals within the environment. During implementation, focus on developing the natural contingencies of reinforcement, teaching enough examples, programming common stimuli, training loosely, using indiscriminable contingencies, and teaching self-management" (p. 107).

SOCIAL VALIDATION

Cooper et al. (1987) state that "behavior analysis efforts that are effective in changing an individual's life in a socially important way are said to have social validity" (p. 56). The concern for social validity has been of primary concern since the beginning of applied behavior analysis. Baer et al. (1968) specified that the domain of applied behavior analysis was "behaviors that are socially important, rather than convenient for study" (p. 92). Wolf (1978) reaffirmed this concern and suggested 3 aspects of social validation: (a) social significance of the goals, i.e., whether society values what is being done; (b) social appropriateness of the procedures, i.e., whether the participants or consumers consider the treatment procedures acceptable; and (c) social importance of the effects, i.e., whether the consumers are satisfied with the results. In addition, Van Houten (1979) suggested two basic approaches for determining the criteria of socially validated performance: (a) use the assessment of individuals judged to be highly competent, and (b) experimentally manipulate different levels of performance to determine empirically which produces optimal results.

The peer tutoring program used in this study has been examined under the 3 aspects of social validity outlined by Wolf (1978). In relation to the program goals, the targeted behaviors are considered prerequisite to
successful completion of more complex mathematics skills. Research has found that peer tutoring creates positive academic effects for the tutors (Dineen, Clark, & Risley, 1977) as well as for tutees. These are skills that are taught in a variety of ways by other educators, within the regular classroom.

In regard to the procedures of the program, the application of the interventions and behavior modifications are appropriate for the educational setting, being only somewhat intrusive. The procedure for the program has been applied across settings and subjects, and has proven to effect behavior in a positive way. Research and use of the program have shown that tutoring is a relatively cost effective insofar as teacher time is concerned to individualized instruction (Cooke et al., 1983). The students have more opportunities to respond and time on task during tutoring, and all students are actively engaged in learning (Greenwood et al., 1987). The tutors could be taught to graph and track their student’s progress throughout the program. The program allows for individualization for each student in the pacing and difficulty of the skills presented. Both a monitoring and a review system are built into program for ease in adjusting or changing the intervention for any student if and when necessary. The system is easily established and maintained, and once the system is installed in the classroom, it is simple to use again. It is also easily adaptable for special situations.

To determine the social validity of the study, the subjects and other staff members involved with the students are usually questioned after the study to measure the effects of the procedure. These measures provide a check with respect to the practical success of the program. Student attitudes toward program will be determined through an exit interview.
CHAPTER III
METHOD

This chapter describes the method used to conduct the study. Included is a description of the subjects, setting, definitions and measurement strategies for the dependent and independent variables, procedures, and experimental design.

Subjects

The subjects for this study were selected because they had not passed the math portion of the Ohio Ninth Grade Proficiency Test on two or more attempts. From a pool of 186 students having not passed the math portion, 31 were scheduled into a study hall period during the morning when the experiment would take place. Thirteen students did not meet the attendance or pretest requirements and six did not choose to participate. Attendance requirements consisted of presence at school on at least 85% of the school days held prior to the beginning of the experiment. Two students of the students were eliminated based on attendance as recommended by the assistant principal. Pretest requirements consisted of a screening test to ensure that student errors were a function of multiplication errors, not other skills embedded with the problem-solving process (e.g., carrying or regrouping errors).

The final set of students consisted of 11 girls and 1 boy from grades 9 and 10. Each student was enrolled in a mathematics class and a study hall
period each day. None of the students in the study was identified as having any
disability, nor did any students receive special education services. The
students ranged in age from 14 years, 6 months to 16 years, 10 months old at
the beginning of the study. Table 1 shows the sex, age, grade placement, and
proficiency test scores on the two administrations of the test prior to the study for
each of the participants.

Letters were sent home, along with consent forms, that described the
study to the parents of the participating students (see Appendix A). Each
consent form was signed and returned before any student took part in the study.

Setting

The study was conducted in Hamilton Local School District, a public
school district, located within a suburban/rural portion of Franklin County,
approximately 10 miles south of Columbus, OH. Permission was obtained from
the superintendent and principal to conduct the study during the high school
students' study hall period. Permission for student participation was also
obtained from students and their study hall teachers.

The study sessions were held in the back of the school library. The
library was divided into 2 sections: the front of the library contained reference
materials, small round study tables, and the circulation desk, and the back
section of the library contained long study tables and bookshelves holding
circulating books. During peer tutoring and partner-administered timed tests,
students sat across from one another at the back of the library in dyads.
Students were seated in a similar fashion for the group timed test, with up to 6
students per table during the timing.
Table 1

Student Characteristics

<table>
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<th>Grade</th>
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<sup>1</sup> Scores are scaled scores from the Ohio Ninth Grade Proficiency Test.

A score of 200 or greater is required to pass the math portion of the test.
Training took place in the back section of the library during the study hall period. In the event the library was closed, or the library was reserved for a class, the study was conducted in either the study hall (cafeteria setting) or the home economics room. The cafeteria setting had long rectangular tables with chairs on both sides. Other students worked in the study hall at other tables. The home economics room had small round tables that seated students in their pairs for peer tutoring or in groups of up to four for the timed test.

Experimenters

The experimenter was a third year doctoral candidate in special education and applied behavior analysis. The experimenter had 6 years of teaching experience in special education classrooms, 1 year at the junior high school level and 5 years at the elementary school level. She also had 4 years experience planning and conducting research in special and general education classrooms. She had worked in the district during the previous school year as an educational consultant. This position was half-time and duties were performed mainly in other schools within the district. She had not worked with any of these students or the study hall teachers previously.

Observers

One observer was trained by the experimenter in one half-hour session. Within this session, the experimenter trained the observer to record information on the observation forms. The observer conducted procedural reliability checks in the experimental setting one or two days per week. The observer was also trained by the experimenter to use a stopwatch and to record the time elapsed accurately. The observer was not informed of the experimental conditions, but
was present in the experimental setting and had the opportunity to observe and to infer information about the study on his own.

A second observer was used for scoring of the student permanent products. This observer was not informed of the conditions of the study and did not know when variables were changed. The second observer marked clean copies of the students' written products, computed the rate and percentage of digits correct, and recorded scores on a data collection sheet.

All tests were scored following the session. An independent scorer was used to conduct accuracy checks on all permanent products for approximately 25% of the sessions. When scoring the papers, the scorers compared each digit in the students' answers with the correct response on an answer key. Matching digits (correct responses) were left unmarked, and digits that did not match were individually circled. The number of correct digits, number of incorrect digits, and the total number of digits written were counted and recorded for each paper.

**Definition and Measurement of the Dependent Variables**

The study was conducted to investigate the rate and percentage of digits correct of 3-digit by 2-digit multiplication problems (319 x 48) solved on a daily 3-minute timed test (see Appendix B for an example of complex multiplication problem test). Rate and percentage of digits correct, and rate of digits correct during peer practice are defined below.

**Rate of Digits Correct**

Rate of digits correct was defined as the number of digits correctly written during the timed test divided by 3 minutes, the time students had available to work. Only written digits in the partial products were used in the calculation.
For example, in the problem 319 X 28, the first partial product yielded 4 digits (2552); the second partial product yielded 3 digits (638); and the final product yielded 4 digits (8932). The sum of these partial products totaled 11 digits (4 + 3 + 4). If students made notations above a multiplicand or addend indicating that a number was being carried or regrouped, that digit was not counted. This time period used for calculating rate of digits correct did not include time spent giving instructions or in practice with the tutor. Time was measured with a stopwatch, and was checked by an independent observer on approximately 25% of the timed tests.

Percentage of Digits Correct

Percentage of digits correct was defined as the number of digits correctly written, divided by the number of digits correctly written plus the number of digits incorrectly written (the total number of digits written through the last problem attempted). This score was converted to a percentage by dividing the denominator by the numerator and multiplying by 100.

Rate of Digits Correct During Peer Practice

Rate of digits correct during peer practice was defined as the number of written responses to a mathematical fact by the student, during the practice portion of the interventions, divided by 3 minutes, the amount of time allowed for peer practice. Each response was counted by the number of digits within the response so comparisons could be made to data collected on students' rates of digits correct on the complex multiplication problem tests. These data represent the number of trials to which students responded correctly during the practice portion of the study.
A permanent product of the number of opportunities to respond was made during the peer tutoring practice and partner-administered time trials by the student. During tutoring, when presented with a flash card, the student said and wrote the answer to the problem in a 2-centimeter square box on a sheet of grid paper. Errors were marked with an "x" by the student and the trial was repeated. The experimenter measured the number of trials provided to the student during tutoring by counting the number of boxes filled during the practice session. Observations were used to check the accuracy of the permanent products and errors were noted to ensure accurate record keeping of student responses.

During the partner-administered time trials, students were timed on basic facts test sheets by their partner. The partner was assigned to keep accurate time of the trial and to stop and start the partner's work. During the group administered time trial on the complex multiplication problems, the experimenter timed the work period. The experimenter counted the number of opportunities the student had to respond by the number of problems the student attempted during each of the types of trials. Problems were counted as incorrect if they were left unanswered within a row when following the order of completion of problems (i.e., top to bottom, left to right). The skipped problems were counted as incorrect trials because the student had an opportunity to answer the problem and chose not to write an answer. This avoided the situation of students selecting only those problems they could easily answer and skipping around the page, keeping the level of difficulty mixed across the experiment.
Accuracy Checks on Math Data Reporting

Since the math problems solved by the students had an absolute true value, the permanent products produced by the students were compared to the true value of the problem. Accuracy checks were conducted independently on 12 of the 41 sessions to ensure that the scorer had marked each digit correctly as correct or incorrect. Interobserver agreement was defined as the number of agreements divided by the number of agreements and disagreements multiplied by 100.

For each discrepancy found during the accuracy checks, the experimenter marked and rescored the student's paper, using a blue ink pen. Corrections were made to the scores already recorded and to the graphs of those scores. If the observer doing the accuracy check was unsure or there was any doubt as to the accuracy of the scoring, the experimenter and accuracy checker consulted to determine the true value.

Definition and Measurement of the Independent Variables

The independent variables consisted of (a) peer tutoring on basic multiplication facts and (b) partner-administered time trials on basic multiplication facts. The second intervention was introduced subsequent to session 28 in an attempt to produce more robust changes in student performance. The steps of the two intervention procedures are detailed in the Procedure section. These steps are also listed on the observation recording form (see Appendix C) and were performed by the experimenter and observer each session.
**Procedural Agreement Measures**

Procedural agreement measures were determined by a review of the observation recording form. The procedural agreement was determined for approximately 25% of the sessions by an independent observer, and was calculated as the percentage of time steps of the independent variables was executed.

Timing of the daily tests was measured by the second observer for approximately 25% of the sessions. The length of time actually allowed for the timed test was determined by the experimenter's and the observer's records. The actual time was accurate to within 2 seconds of the expected 3 minute timing. Since accurate "count down" timers were used, little variability and no errors occurred.

**Generality Measures**

Stimulus generality occurs when a target behavior is emitted in the presence of stimulus conditions that differ from those in which it was trained directly. The extension of an individual's behavior across settings, time, and response as a function of previous treatment in another setting and/or another behavior, is generality. In this experiment, students received practice on basic multiplication facts in a peer tutoring format or on a partner-administered time trial. Response generality was recorded by measuring the rate and percentage of digits correct on complex multiplication problems that were calculated by the students on a timed test of complex multiplication problems. This is considered to be response generality because the students did not receive intervention in the complex multiplication problems being measured, but rather in a more basic skill. The complex multiplication problems were tested to determine if any
relation existed between practicing basic facts (and increasing the rate and/or percentage of digits correct on the basic facts) to the more complex skill.

**Maintenance Measures**

Maintenance is the extent to which the learner continues to perform the target behavior, trained tutoring and accurate timing procedures, after a portion or all of the intervention has been terminated. Maintenance was recorded by noting the performance of the target behaviors subsequent to the training session. Data were collected during peer tutoring and partner-administered time trials sessions. Each tutor/student pair was observed for maintenance of tutoring and accurate timing procedures in approximately 25% of the sessions.

**Social Validity**

The math portion of the Ohio Ninth Grade Proficiency Test would be the best measure of effectiveness and social validity for this study. Because the Ohio proficiency test is a state-regulated test, it could not be accessed or administered after the study to determine effectiveness. Other social validity measures of student opinion and teacher observations were used to determine the validity of the study.

**Social validation of student opinions.** Data concerning social validity were collected from the students involved in the study one and one half weeks after the study was terminated. Students were interviewed individually by the experimenter in informally in an adjacent outdoor courtyard. The interviewer asked questions such as: "How did you feel about working with a partner?", "What was the best part?", and "What part did you like the least?" The interviewer asked the student to elaborate on his or her answers by asking "Why?" These data were collected by recording the interview on a tape
recorder (see Appendix D for Social Validity questionnaire). The data were compiled, a content analysis performed, and the results discussed. Student opinion was determined by comparing, analyzing, and summarizing the patterns of student answers to the questions posed in the interview.

**Teacher perceptions.** The mathematics and study hall teachers that dealt directly with the students were given a questionnaire. They were asked about any noted changes in the students' mathematics performance. The survey asked the staff member to compare the math performance and the self-confidence levels of the student involved in the study to the student's previous performances.

**Materials**

The following materials were used during the experiment. A detailed description of each of the experimenter-made materials is given.

**Writing supplies.** Students used black ink pens to write all answers during the experiment. The black pens were chosen so that clear copies of the students permanent products could be made. The copies were used for accuracy checks and as backup data in case of loss or damage. Red pens were used by the students to score the partner-administered time trials during that condition. All pens were commercially produced round stick pens with medium points.

**Complex multiplication problem tests.** All math tests were prepared by the experimenter. The tests were printed on the computer and copied on 21.7 cm x 28 cm white paper (for an example, see Appendix B). The tests consisted of 32 complex multiplication problems. Each sheet had 4 rows of 9 problems. The skills to be covered included multiplication problems with multiplicands
from 10 to 99. Each sheet consisted of a random selection of problems, with the range of multiplication facts within each problem being distributed equally across the sheet. There were 8 test forms used in random order throughout the study. This random order was used so students would not learn to respond to the problems in a memorized sequence. All possible facts were represented 4 or 5 times on each sheet (e.g., 364 x 82 represents the facts 2 x 4, 2 x 6, 2 x 3, 8 x 4, 8 x 6, and 8 x 3), with no two problems being exactly alike. Rather than making the problem sheets more difficult later in the study as students had more practice on the problems, the goal was to keep the level of difficulty consistent throughout the experiment by using the same test sheets with more problems than the students could possibly solve in 3 minutes.

**Basic fact tests.** All basic fact tests were prepared by the experimenter using a method similar to that used for the complex problems. That is, the tests were printed on the computer and copied on 21.7 cm x 28 cm white paper (for an example, see Appendix B). The tests consisted of 72 basic multiplication facts. Each sheet had 6 rows of 12 problems. The skills to be covered include multiplication facts from 0 x 0 to 9 x 9. Each sheet consisted of a random selection of facts, with the range of multiplication facts being distributed equally across each sheet. There were 6 fact sheet forms used in random order throughout the study so students would not learn to respond to the facts in a memorized sequence. All possible facts were represented 4 or 5 times across the 6 sheets. Rather than making the problem sheets more difficult later in the study as students have more practice on the problems, the goal was to keep the level of difficulty consistent throughout the experiment by using the same test sheets with more problems than anyone could possibly solve in 1 minute. If a
student was able to work more than 72 facts in 1 minute, the student calculated answers on a second sheet that was attached to the first.

**Answer keys.** Each form of the math time trials--complex problems and the basic fact sheets--had a corresponding answer key prepared by the experimenter. The answer keys were made from a copy of the test form with the answers written in red ink. The answer keys were checked for accuracy with a calculator. The answer keys for the complex problems showed the long form of the answer. The answer keys were used to compare the student answers to the absolute true value to each complex problem or basic fact. Student tests of complex problems were scored with the answer key by the experimenter and by the second observer. Student tests of basic facts were scored with the answer key by the student's partner and by the experimenter.

**Data sheets and graphs.** The experimenter kept data sheets and graphs to record the rate and percentage of digits correct of the students' performances. The data sheets contained a space for the name of each student participating in the study and room to record the results of the daily timed test. A section of the sheet was used to record interobserver agreement on the students' rate and percentage of digits correct as well as the accuracy of the scores reported. Graphs were plotted each day after the written products were scored. Two graphs were kept for each student: one showing rate and percentage of digits correct on the complex multiplication problem test, and one showing the rate of digits correct during peer practice (under both peer tutoring and partner-administered time trials conditions).

**Tutoring folders.** The tutoring folders were prepared by the experimenter prior to the study. The folders were used to hold the tutoring supplies or basic
fact time trial sheets the students would be using during the day's session. Each student had a 23 cm x 30.5 cm colored 2-pocket Duo-Tang brand folder that was used to hold their materials. The name of the student was written on the front of the folder in black marker. The inside left pocket was labeled "Materials" and contained pieces of 2-centimeter grid paper, 2 black pens, and an instruction sheet during the peer tutoring condition, or held 3 basic fact time trials sheets, one black pen and one red pen during the partner-administered time trials. The inside right pocket was labeled "Study" and contained the basic multiplication fact cards to be studied by the student with the tutor during the peer tutoring condition. During the partner-administered time trials, the "Study" pocket contained the corrected time trial tests from the previous session. This design was adapted from Cooke, Heron, and Heward (1983).

**Basic multiplication fact cards.** The fact cards used during this study were obtained from a box of commercially produced multiplication flash cards. The flash cards were made of laminated tag board and measured 16 cm x 8.5 cm. The cards were manufactured by Media Materials of Baltimore, MD. Each card had one multiplication fact written vertically on one side and the same fact with the answer printed on the other side. These flash cards were used by the tutors during the practice portion of the peer tutoring condition. Multiplication facts used were the 100 basic facts (e.g., 0 x 0 to 9 x 9).

**Timers.** A West Bend digital battery-operated timer was used by the experimenter. The second observer used a digital timer for reliability checks on the timing of the tests. During the partner-administered time trials, the students used the same digital timers as the experimenter. Due to a shortage of timers,
one team was taught to use a stop watch accurately. This was an Eddie Bauer digital battery-operated stop watch.

Experimental Design

The experiment was run across a 10-week period, 5 days per week. The length of each condition was determined by graphic analysis of individual student responses.

The dependent variable was measured using a multiple-baseline design across students. Conditions varied between: (a) baseline, a condition of no intervention, (b) reciprocal peer tutoring, a condition in which the student and a partner took turns as tutor and student, practicing basic multiplication facts for 3-minutes each, and (c) partner-administered time trials, a condition in which the student and partner took turns being timed on three 1-minute time trials of basic multiplication facts. The independent variables were applied sequentially to the students. Students who received the intervention at a later time took the timed tests less often than students receiving the intervention.

Procedure

The following section describes the procedures for general experimental procedure, assessment, testing, feedback to the students, tutoring practice, partner-administered time trials, and observation.

General Experimental Procedure

During all experimental conditions, the experimenter sat or stood near the middle of the room on the side. Occasionally, she walked around the room, monitored the work of the students, and verbally praised appropriate tutoring behaviors, but she did not otherwise interact with the students unless the behavior of a student warranted redirection. Also, the observer sat or stood
near the middle of the room during observation sessions. The experimenter and the observer sat or stood in close proximity to the pairs during the peer tutoring or partner-administered time trials sessions, but not so close as to be able to determine the markings of the other observer. The second observer never attended an experimental session.

**Student Assessment**

A pre-experimental assessment was administered to the students to determine current levels of rate and percentage of digits correct on complex multiplication problems. The assessment consisted of one of the timed test that was used during the experiment. The experimenter administered the timed test over complex multiplication problems in the same way described in the procedure for administration during the experiment. The pre-experimental assessment was given in the library during the students' study hall period.

Assessments were administered to determine appropriateness of the complex multiplication problem sheets and to select students for the study. This assessment was used specifically to determine each student's ability to perform carrying within the complex problems.

Prior to the assessment, students were given a brief orientation training. The training consisted of 1 orientation session, lasting approximately 15 minutes. The experimenter provided a brief overview of the study to the students, and instructions on taking the timed tests.

**Timed Tests**

A timed test on complex multiplication problems was administered every day at the end of the session. Test sheets for this condition contained 36 complex multiplication problems. The 8 test forms were used in random order.
Distribution of the tests and black pens took place before the timing of the session began. The experimenter placed the tests face down on the students' desks and told students not to turn the sheet over until given the signal to do so.

The experimenter gave instructions when all students had a test in front of them. Prior to the time trial, the experimenter's instructions included statements such as, "Do not turn the test over or start work until I tell you to do so. When it is time to work, I want you to work as fast as you can and try your best, answering as many problems correctly as you can in the 3 minutes. Don't worry if you do not finish, there are more problems on the test than anyone can do in 3 minutes. Just try your best. Please do the problems in order (left to right and top to bottom of the page) and don't skip any problems. Remember to work quickly and carefully to try to get the problems correct. When it's time to stop, the timer will beep and I will say "Stop working". Please stop immediately and do not write any more."

The experimenter asked "Is everyone ready?" Students indicated they were ready to begin by looking at the experimenter. This procedure was used to indicate student readiness for the time trial and to prevent students from looking at the test sheet prior to the beginning of the trial. When students were ready, the experimenter coordinated the timing of the session.

To begin the time trial, the experimenter used the commands, "Ready? And. GO." With the cue "Ready?", the students prepared to turn the test over, by holding the corner of the test. "And" was the cue for students to turn over the test to expose the problems they would work on. "GO" was the command to begin work. With this cue the experimenter began the 3-minute time trial and
simultaneously started the timer. The test was timed by the experimenter with an accurate count-down timer.

At the end of exactly three minutes, indicated by the beeping of the timer, the experimenter said, "Stop writing. Pass in the tests. Thank you for working with me today, you may return to your normal study hall activities." The experimenter collected the tests and the pens as the students returned to their regular seats in the library or returned to study hall.

During the experiment, the experimenter closely used this script. During approximately 25% of the sessions, the observer checked for procedural reliability of the instructions as the students were given the test procedures. The experimenter continued to ask students to try their hardest and work as fast as they could each day.

The experimenter recorded and graphed rate and percentage of digits correct data daily. Papers were marked by circling incorrect digits within answers to the problems. A line was drawn after the last completed digit on the sheet to assure no additional problems were completed during the review of tests the next session. Student scores were marked at the top of the sheet showing number of digits correct over total number of digits completed. Scored tests, with scores and comments on the top, were returned the next session prior to the time trial. These procedures were followed throughout the experiment for the 3-minute time trial of complex multiplication problems.

Feedback to the Students

Feedback information was given to the students in the form of a fractional score and a written comment. Feedback statements were written on the students' tests to give them information about their performance and to
encourage students to keep trying. If the score for the day was lower than their highest score for the previously worked tests, comments such as "Keep trying, Sally!", "Work as fast as you can", or "Work carefully" were written. If the score for the day was the student's highest ever during the experiment, a new high score, written comments such as "Best score ever!" were used. In the event the student tied his or her best score, the comment "This ties your best score" was written. The written statements contained one of these three types of messages, and all statements of the same type were of similar length and wording. On the first day of the experiment, all students received a written statement that they did a nice job (i.e., "Good work!" "Nice work, today!"). Before the beginning of each session, tests were returned to the students from the prior day's session for them to view. The tests were immediately collected and kept as permanent products by the experimenter.

Tutoring Procedure

A treatment package was developed and was composed of the following components: practicing of multiplication basic facts, prompting, and praising. This tutoring package was a modified version of a reciprocal peer tutoring program for math facts developed by Cooke, Heron, and Heward (1983). Changes were made in the number of math facts placed in the "Go" pocket. The "Go" pocket was renamed the "Study" pocket because of the age and grade level of the students. Cards were placed in the "Study" pocket based on any mistakes made during the previous day's timed test. Facts were also placed in the "Study" pocket if the student has been observed making a hesitation on the fact, or facts were randomly selected from the more difficult facts (6 x 6 through 9
x 9) when no errors were observed. The students differed in number, age, grade level, and disability from those used in the program cited above.

Peer tutoring training. This section provides a brief overall description of the training session for peer tutoring. The actual scripts used for the training session are presented in Appendix E. The experimenter conducted the training session in the library where the experiment took place. The observer was present to check for procedural reliability during the training sessions. This procedure also allowed students to become familiar with the observer.

Tutor training was conducted in one session. The training session lasted approximately one-half hour and was held during the time set aside for peer tutoring. The training session was held, and immediately following training, during the same class period, the peer tutoring intervention was implemented. Student pairs were trained immediately before the implementation of the peer tutoring condition for their pair. The experimenter provided all of the necessary materials, and led the students through the tutoring process step-by-step. Both students in each pair were taught tutoring skills and student behaviors during the training session.

The procedures for the peer tutoring training sessions were explained and practiced using 3 teaching methods. The methods included: (a) explanation of the skill being presented, (b) teacher modeling of the skill, and (c) student practice by the involved pairs with teacher prompts. A short explanation of the teaching methods mentioned above are given here for use in the replication of the study. Explanation and/or description of the skill were done by presenting an oral description of the skill and explanation as to why it was included. The actual materials were used to clarify a point. Since the
the experimenter modeled the skill, the students were given a concrete example of the response requirements. This took place by the experimenter showing exactly what behavior the students were expected to perform, with examples and non-examples. The tutoring pair then practiced the skill learned with their assigned tutoring partner. During this time the experimenter monitored the student pairs and helped any student that had trouble or did not follow the procedures. The experimenter praised the students who performed the skills correctly and corrected mistakes by the students or tutors as they occurred.

Tutoring skills and student behaviors. Students were taught the skills necessary to be peer tutors and those behaviors expected of the student in the training session. Actual peer tutoring sessions began immediately the same day that training was completed. Each of the daily peer tutoring practice sessions consisted of 3 parts; Practice-1, Practice-2, and Clean up.

Students were assigned packets of basic multiplication fact cards to learn. Each packet contained 10 cards, with one fact on each. The facts to be practiced included any facts for which the student wrote a digit incorrectly on the previous day's timed test and any facts on which the student had been observed by the tutor to hesitate during previous practice. Facts on which the student hesitated were determined by the tutor or the experimenter and were defined as those facts on which the student did not give an answer on two or more trials during a peer tutoring practice session. If no errors were noted, facts for practice were randomly selected from the difficult facts (6 x 6 to 9 x 9).

In the peer tutoring practice, the tutor was expected to show the student his or her facts, correct errors, and drill for speed. Praising was an important part of the tutoring practice and it occurred at the end of each session. This part
of the tutoring package is explained below, but is not a separate part of the peer tutoring sessions.

"Practice" was the term used to identify each of the two 3-minute parts of the tutoring session in which the actual practice of the multiplication facts occurred. The tutoring pairs went to their assigned spots and faced one another with their folders opened between them. The tutor removed the student's facts from the "Study" pocket and presented them to the student one fact at a time. As the tutor showed the fact flash card, the student wrote and said the answer to the basic fact presented. The answers were recorded by the student on the grid paper provided in the folder. If the student solved the fact correctly, the tutor proceeded to the next fact. If the student solved the fact incorrectly, the tutor said, "Try again." The student then crossed out the answer he or she wrote incorrectly and again attempted the problem. If the student hesitated longer than 3 seconds with no response the first time the fact was presented, the tutor said, "Try it." If the fact was then correctly solved, the tutor went to the next fact card. If again, the response was too slow or incorrect, the tutor was taught to prompt the student by saying, "Say (8 x 3 = 24)." The student then repeated the entire fact and answer, wrote the correct answer to the fact on the grid paper, and the pair continued on with the next fact card. After the tutor and student practiced each card, the tutor shuffled the cards, praised the student for good work, and then repeated the practice for the stack of shuffled fact cards. The tutor was instructed to go through the stack of fact cards as many times as possible within the practice time allotted. At the end of the 3 minute period, the tutor and student reversed roles and engaged in a second practice session. To avoid a practice sequence effect, the students took turns being the first student
to be tutored. Each day was assigned alternately as an A or B day, an students were assigned a letter. The letter was written on the front of the student's materials folder. The experimenter announced if it was A or B day to be tutored first.

Tutors were trained to praise their students during the practice sessions. Through the same methods used in earlier training sessions, tutors were taught examples and non-examples of praise statements. The students were taught to give a reinforcing statement at the end of each pass through the cards. As the tutor shuffled the flash cards, a praise statement was issued to the partner. Also, the tutor was instructed to praise at the end of the session.

The student kept track of the number of learning opportunities presented to him or her in the practice session. The tutor was asked to ensure that the student wrote an answer for every flash card trial presented. A learning opportunity or trial was defined as a presentation of a card or a "Try again" prompt. A check of the number of answers written by the student on the grid paper during tutoring provided information on the number of trials presented. This information was verified by comparing it with observational data collected by the experimenter and the observer.

**Partner-Administered Time Trial Procedure**

In looking for a more robust change in student responding on complex multiplication problems, the experimenter made a change in the intervention procedures during the study. Partner-administered time trials were implemented as a replacement for the peer tutoring intervention.

Daily partner-administered time trials training. This section provides a brief overall description of the training session for partner-administered time
trials. The actual scripts used for the training session are presented in Appendix E. The experimenter conducted the training session in the library where the experiment took place. The observer was present to check for procedural reliability during the training sessions. This procedure also allowed students to become familiar with the observer.

The training session lasted approximately one-half hour and was held during the time set aside for partner-administered time trials. The training session was held, and immediately following training, during the same class period, the partner-administered time trial intervention was implemented for the pair. In one case, the partners were trained in the procedures after the completion of the session on the day before their actual first time trial session was to occur. The experimenter provided all of the necessary materials, and led the students through the tutoring process step-by-step. Both students in each pair were taught timing skills and student behaviors during the training session.

The procedures for the partner-administered time trial sessions were explained and practiced using 3 teaching methods. The methods included: (a) explanation of the skill being presented, (b) teacher modeling of the skill, and (c) student practice by the involved pairs with teacher prompts. A short explanation of the teaching methods mentioned above are given here for use in the replication of the study. Explanation and/or description of the skill were done by presenting an oral description of the skill and explanation as to why it was included. The actual materials were used to clarify a point. Since the experimenter modeled the skill, the students were given a concrete example of the response requirements. This took place by the experimenter showing exactly what behavior the students were expected to perform, with examples
and non-examples. The students then practiced the skill learned with their assigned partner. During this time the experimenter monitored the student pairs and helped any student that had trouble or did not follow the procedures. The experimenter praised the students who performed the skills correctly and corrected mistakes by the student or the timer as they occurred.

**Time trial skills and student behaviors.** Each of the daily partner-administered time trials sessions consisted of 4 parts: review of previous day's time trial sheets, time trials (test-A1, test-B1, test-A2, test-B2, test-A3, test-B3), scoring of one selected time trial, and clean up. A set of three 1-minute time trial tests of basic multiplication facts was administered to each student individually during the session, every day of this phase of the experiment. Students in the pairs took turns being the time trial administrator and the student.

Test sheets for this condition contained 72 basic multiplication facts. Each student took 3 tests each session during this condition. The sheets were used in random order, with the 6 sheets being randomly assigned between the two students of the pair. Again, the goal was to provide enough problems at a level of difficulty that would not necessitate changes to the sheets as student skill level increased. When two students were able to perform more than 72 basic facts per minute, they were given two fact sheets stapled together for each 1-minute time trial. The second sheet was used as a continuation, making 144 facts available as opportunities for the students to respond.

The students were instructed to work on the problems in order of appearance from left to right and top to bottom of the page. Distribution of the folders, including the previous day's tests, tests for the session, and a black and a red pen, took place before the timing portion of the session began. The
experimenter placed the folders on the students' desks and told the students to first review the test sheets from the previous session.

The experimenter gave instructions when all students were seated. Prior to the time trial portion of the session, the experimenter's instructions included statements such as, "Please review your time trial sheets from yesterday (or the previous session). Try to improve on any mistakes you made and try to go faster on today's timings. Today is A day. Students with an A on their folder are tested first today. When you are administering the tests, remember to time your partner accurately. The idea is to help your partner go as fast as possible on the time trial. When you are taking your test, remember to work as fast as you can and try your best, answering as many problems correctly as you can in 1 minute. Try your best." The experimenter told the students to begin as soon as both partners had reviewed their previous day's tests.

To begin the 1-minute time trial, the administrating partner used the commands, "Ready? And. GO." The words "Ready?" and "And" were used by the administrating partner as cues to prepare to be timed. "GO" was the command to begin work. With this cue the partner began the 1-minute time trial and simultaneously begin the timer. The test was timed by the partner with an accurate count-down timer.

At the end of exactly one minute, indicated by the beeping of the timer, the partner said, "Stop writing." The administrating partner praised the student and made a comment about the speed when appropriate. The partners then switched roles until each student had taken three 1-minute time trials.

When all the time trials had been administered, the students each selected one of their partners' time trial sheets for grading. Using a red pen,
any problems answered incorrectly were circled and corrected on the students' papers. The number of problems answered correctly was totaled and written at the top of the page as a ratio of the number of problems attempted. The paper that was scored was returned to the owner for immediate feedback.

The experimenter scored all papers each day. She recorded and graphed rate data daily. Papers were marked by circling incorrect answers within answers to the problems. A line was drawn after the last completed problem on the sheet to ensure no additional problems were completed during the review of tests the next session. Student scores were marked at the top of the sheet showing the ratio of correct problems over total number of problems completed. Scored tests, with scores written on the top, were returned the next session prior to the partner-administered time trials. These procedures were followed throughout this condition of the experiment for 1-minute time trials of basic multiplication facts.

**Experimenter's Role**

When a student was observed making an error, the experimenter demonstrated the trained procedures again. Also, the experimenter was responsible for preparation of the materials and timing peer tutoring practice sessions and complex multiplication problem tests. The experimenter observed each task that students performed.

The experimenter was responsible for arranging reinforcing consequences for the participants of the study for their participation. A "pizza" party was held at the end of the experiment after all data were collected, including social validity measures. This party was arranged as a "closure" activity for student participation and was not contingent on math performance.
CHAPTER IV
RESULTS

This chapter presents the results of the study. Data were obtained on interobserver agreements for the independent and dependent variables. Further, student data are reported for the rate of digits correct during peer practice conditions, rate and percentage of digits correct on 3-minute timed tests of complex multiplication problems, and social validity measures.

Interobserver Agreement Scores

Interobserver agreement (IOA) measures were obtained for the independent variables (procedural IOA), and the dependent variables (i.e., rate of digits correct during peer practice, and rate and percentage of digits correct for complex multiplication problems). The agreement scores were calculated by dividing the number of agreements (e.g., correct or incorrect digits) by the total number of agreements plus disagreements (total number of student responses) and multiplying by 100. The mean and range of interobserver agreement scores were calculated for each condition and tier of the design.

Procedural Reliability

To ensure that the procedures for the experiment were followed closely, the experimenter used a checklist when providing directions. Procedural reliability was measured by the observer with the same checklist. The original checklist contained 24 items that constituted the daily procedures of the experiment. During baseline and peer tutoring conditions, 8 sessions were
checked for procedural reliability. After the time trials condition was added for some students, procedural reliability was checked in 4 additional sessions for a total of 12 procedural checks. The observer marked all items on the checklist independently. Included in this checklist was an accuracy check on the length of the timed test that students were administered. Procedural reliability checks were conducted at least once during each week of the study. Procedural IOA checks yielded a mean of 98.6%, with a range of 95.8% to 100% of procedures followed (see Table 2). On one occasion, the procedures were not followed because the experimenter did not indicate to students if it was A or B day. Students prompted the experimenter. Another session was not scored as 100% because the observer did not time the session accurately due to a malfunction of the observer's timer. In the third instance, the experimenter neglected to show students their test sheets from the previous session because they were left at home, but did read the scores of those tests to the students. A fourth discrepancy in procedures was noted when the experimenter's timer was not activated properly and she timed the 3-minute timed test of complex problems on her wristwatch.

**Rate of Digits Correct During Peer Practice**

During the intervention conditions of this study, students practiced with a peer for the 3-minute timed test of complex multiplication problems by writing responses to basic multiplication facts. The rate of digits correct during the peer practice segments of peer tutoring and partner-administered time trials were checked for accuracy by a second observer.

Table 3 shows the agreement scores on rate of digits correct during peer practice made by the observer. When disagreements occurred, checks and
Table 2

Procedural Interobserver Agreement for Peer Tutoring and Time Trials

<table>
<thead>
<tr>
<th>Session</th>
<th>Percentage of Procedures Followed</th>
</tr>
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<tr>
<td></td>
<td>(N=24)</td>
</tr>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>95.8</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
</tr>
<tr>
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<tr>
<td>11</td>
<td>95.8</td>
</tr>
<tr>
<td>12</td>
<td>100</td>
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Table 3

<table>
<thead>
<tr>
<th>Student</th>
<th>Peer Tutoring</th>
<th>Time Trials</th>
<th>Grand Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Sessions)</td>
<td>Range</td>
<td>Mean (Sessions)</td>
</tr>
<tr>
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<td>97.6-100</td>
<td>99.6 (4)</td>
</tr>
<tr>
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</tr>
<tr>
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<td>99.4-100</td>
<td>99.3 (3)</td>
</tr>
<tr>
<td>4</td>
<td>99.3 (2)</td>
<td>98.0-100</td>
<td>99.2 (4)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>98.5 (4)</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>12</td>
<td>100 (1)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Grand Mean</td>
<td>99.4 (10)</td>
<td>97.6-100</td>
<td>99.4(32)</td>
</tr>
</tbody>
</table>

* Numbers within the parenthesis indicate number of sessions checked for IOA in that condition.
corrections were made to the total calculations for the number correct, number
attempted, rate of digits correct, and the graphing of those scores.

**Rate and Percentage of Digits Correct on Complex Multiplication Problems**

Student were given a daily 3-minute timed test on complex multiplication
problems. The written responses made by the students on this daily test of
complex multiplication problems were checked for accuracy by a second
observer. Table 4 shows the agreement scores for written responses made by
the observer. When disagreements occurred, checks and corrections were
made to the total calculations for the number correct, number attempted, rate
and percentage of digits correct, and the graphing of those scores.

**Rate of Digits Correct During Peer Practice**

**Student 1.** Student 1 was present for a total of 33 of the 41 sessions.
She missed sessions 2, 7, 14, 16, 17, 18, 19, and 23. She was tutored by
Student 2. Student 1 participated in baseline from session 1 to 12, peer tutoring
during sessions 13 to 28, and partner-administered time trials for sessions 29 to
41.

Figure 1 (upper tier, left) shows the rate of digits correct during peer
practice written by Student 1 during peer tutoring and partner-administered time
trials. During baseline, written practice did not occur in the study hall or in the
classroom. In the peer tutoring condition, the rate of digits correct during peer
practice for Student 1 averaged 60.0 digits correct per minute, with a range from
49 digits correct to 68 digits correct.

In the peer tutoring condition, Student 1's rate of digits correct during
peer practice was variable and showed an increasing trend. During the
partner-administered time trial condition, her rate of digits correct during
<table>
<thead>
<tr>
<th>Student</th>
<th>Baseline</th>
<th>Peer Tutoring</th>
<th>Time Trials</th>
<th>Grand Mean</th>
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<td>Range</td>
<td>Mean</td>
<td>Range</td>
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<td>99.7(3) 99.3-100</td>
<td>100(4) 100</td>
</tr>
<tr>
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<td>99.1-100</td>
<td>99.6(2) 99.2-100</td>
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</tr>
<tr>
<td>4</td>
<td>97.7(6)</td>
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</tr>
<tr>
<td>5</td>
<td>99.9(7)</td>
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<tr>
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</tr>
<tr>
<td>7</td>
<td>98.5(8)</td>
<td>93.1-100</td>
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<tr>
<td>8</td>
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<td>93.6-100</td>
<td></td>
<td>99.8(3) 99.2-100</td>
</tr>
<tr>
<td>9</td>
<td>99.1(10)</td>
<td>92-100</td>
<td></td>
<td>100(2) 100</td>
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<tr>
<td>10</td>
<td>99.9(10)</td>
<td>99.1-100</td>
<td></td>
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<tr>
<td>11</td>
<td>99.6(11)</td>
<td>98.7-100</td>
<td></td>
<td>100(1) 100</td>
</tr>
<tr>
<td>12</td>
<td>99.9(9)</td>
<td>99.1-100</td>
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<td>100(1) 100</td>
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<tr>
<td>Grand Mean</td>
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<td>99.8(10) 99.2-100</td>
<td>99.9(35) 99.2-100</td>
<td>99.6</td>
</tr>
</tbody>
</table>

a Numbers within the parenthesis indicate number of sessions IOA's checked in that condition.
Figure 1. Rate of digits correct during peer practice.
practice averaged 101.6, an increase in mean of 41.6 digits correct per minute over the peer tutoring condition. Rate of digits correct during practice for Student 1 during the time trials condition ranged from 86.3 digits correct to 115 digits correct. When the partner-administered time trial condition was implemented, her rate of digits correct during practice increased considerably, showed less variability, and increased sharply.

**Student 2.** Student 2 was present for a total of 32 of the 41 sessions. He missed sessions 2, 7, 12, 14, 16, 17, 18, 19, and 23. He was tutored by Student 1. Student 2 participated in baseline from session 1 to 12, peer tutoring during sessions 13 to 28, and partner-administered time trials for sessions 29 to 41.

Figure 1 (upper tier, right) shows the rate of digits correct during peer practice by Student 2 during peer tutoring and partner-administered time trials. In the baseline condition, written practice did not occur in the study hall or in the classroom. The rate of digits correct during practice by Student 2 in the peer tutoring condition averaged 58.9 digits correct per minute, with a range from 51.0 to 76.0 digits correct. Student 2's rate of digits correct during practice was slightly variable during the peer tutoring condition and showed an increasing trend. During the partner-administered time trial condition, his rate of digits correct during practice had a mean of 99.1 digits correct, an increase in mean of 40.2 digits correct per minute over the peer tutoring condition. Rate of digits correct during practice by Student 2 in the time trials condition, ranged from 89.3 to 110.0 digits correct per minute. During the partner-administered time trial condition, the slope of his rate of digits correct during practice showed only a small increasing trend, but the level averaged 15 digits per minute more than the highest data point in peer tutoring.
**Student 3.** Student 3 was present for a total of 31 of the 41 sessions. She missed sessions 2, 6, 7, 14, 16, 23, 28, 35, 37, and 39. She was tutored by Student 4. Student 3 participated in baseline from session 1 to 20, peer tutoring during sessions 21 to 28, and partner-administered time trials for sessions 29 to 41.

Figure 1 (second tier, left) shows the rate of digits correct during practice by Student 3 during peer tutoring and partner-administered time trials. In the baseline condition, written practice did not occur in the study hall or in the classroom. In the peer tutoring condition, the rate of digits correct during practice by Student 3 averaged 50.8 digits correct per minute, with a range from 46.3 to 58.7 digits correct. Student 3's rate of digits correct during practice was quite steady during the peer tutoring. During the partner-administered time trial condition, her rate of digits correct during practice averaged 79.9 digits correct per minute, an increase in mean of 29.1 digits correct over the peer tutoring condition. Rate of digits correct during practice for Student 3 during the time trials condition, ranged from 82.5 to 100.7 digits correct per minute. Her rate of digits correct during practice in the peer tutoring condition was stable. When the intervention was changed, her rate of digits correct during practice increased to over 20 digits correct per minute. During the partner-administered time trial condition, Student 3's rate of digits correct during practice was increasing across the first six sessions, then showed a decreasing trend until the end of the experiment.

**Student 4.** Student 4 was present for a total of 31 of the 41 sessions. She missed sessions 2, 6, 7, 13, 14, 16, 23, 28, 37, and 41. She was tutored by Student 3. Student 4 participated in baseline for sessions 1 to 20, peer tutoring
during sessions 21 to 28, and partner-administered time trials for sessions 29 to 41.

Figure 1 (second tier, right) shows the rate of digits correct during practice by Student 4 during peer tutoring and partner-administered time trials conditions. In the baseline condition, written practice did not occur. In the peer tutoring condition, the mean rate of digits correct during practice by Student 4 was 45.5 digits correct per minute, with a range from 30.7 to 60.0 digits correct. During the peer tutoring condition, Student 4's rate of digits correct during practice showed a sharply increasing trend with great variability. During the partner-administered time trial condition, her mean rate of digits correct during practice was 81.9 digits correct per minute, an increase in mean of 36.4 digits correct per minute over the peer tutoring condition. Rate of digits correct during practice for Student 4 during the time trials condition, ranged from 71.0 to 93.0 digits correct. In the partner-administered time trial condition, her rate of digits correct during practice increased, showed less variability, and an ascending trend.

Student 5. Student 5 was present for a total of 34 of the 41 sessions. She missed sessions 2, 7, 10, 11, 12, 13, and 16. She was tutored by Student 6. Student 5 participated in baseline during sessions 1 to 28 and partner-administered time trials for sessions 29 to 41.

Figure 1 (third tier, left) shows the rate of digits correct during practice by Student 5 during baseline and partner-administered time trials. In the baseline condition, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice by Student 5 averaged 77.9 digits correct per minute, with a range from 69.0 to 87.3 digits correct. During
the partner-administered time trial condition, her rate of digits correct during practice showed a slightly increasing trend with variability during the middle sessions (33 to 35).

**Student 6.** Student 6 was present for a total of 34 of the 41 sessions. She missed sessions 2, 6, 7, 10, 15, 16, and 39. She was tutored by Student 5. Student 6 participated in baseline during sessions 1 to 28 and partner-administered time trials for sessions 29 to 41.

Figure 1 (third tier, right) shows the rate of digits correct during practice by Student 6 during baseline and partner-administered time trials. In the baseline condition, no written practice took place. In the partner-administered time trials condition, the rate of digits correct during practice by Student 6 averaged 113.9 digits correct per minute, with a range from 98.3 to 122.3 digits correct per minute. During the partner-administered time trial condition, her rate of digits correct during practice was somewhat variable and showed an increasing trend.

**Student 7.** Student 7 was present for a total of 33 of the 41 sessions. She missed sessions 1, 2, 6, 7, 14, 16, 28, and 39. She was tutored by Student 8. Student 7 participated in baseline during sessions 1 to 34 and partner-administered time trials for sessions 35 to 41.

Figure 1 (fourth tier, left) shows the rate of digits correct during practice by Student 7 during baseline and partner-administered time trials. In the baseline condition, no written practice took place. In the partner-administered time trials condition, the rate of digits correct during practice of Student 7 averaged 78.6 correct digits per minute, with a range from 69.0 to 90.3 digits correct per minute. During the partner-administered time trial condition, her rate
of digits correct during practice showed a sharply increasing trend over the first four sessions of the condition, and a decreased rate of digits correct during practice in the final two sessions.

**Student 8.** Student 8 was present for a total of 32 of the 41 sessions. She missed sessions 2, 6, 7, 14, 15, 16, 22, 28, and 39. She was tutored by Student 7. Student 8 participated in baseline during sessions 1 to 34 and partner-administered time trials for sessions 35 to 41.

Figure 1 (fourth tier, right) shows the rate of digits correct during practice by Student 8 during baseline and partner-administered time trials. In the baseline condition, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice by Student 8 averaged 102.6 correct digits per minute, with a range from 97.3 to 115.7 digits correct per minute. During the partner-administered time trial condition, her rate of digits correct during practice was very stable across the first five sessions and rose sharply (17 digits per minute) in the final session.

**Student 9.** Student 9 was present for a total of 32 of the 41 sessions. She missed sessions 14, 20, 22, 27, 29, 31, and 39. She was tutored by Student 10. Student 9 participated in baseline during sessions 1 to 36 and partner-administered time trials for sessions 37 to 41.

Figure 1 (fifth tier, left) shows the rate of digits correct during practice by Student 9 during baseline and partner-administered time trials. In the baseline condition, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice of Student 9 averaged 70.1 digits correct per minute, with a range from 63.3 to 77.7 digits correct per
minute. During the partner-administered time trial condition, her rate of digits correct during practice showed an increasing trend with variability.

**Student 10.** Student 10 was present for a total of 37 of the 41 sessions. She missed sessions 14, 31, 33, and 39. She was tutored by Student 9. Student 10 participated in baseline during sessions 1 to 36 and partner-administered time trials for sessions 37 to 41.

Figure 1 (fifth tier, right) shows the rate of digits correct during practice by Student 10 during baseline and partner-administered time trials. In the baseline condition, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice of Student 10 averaged 125.0 digits correct per minute, with a range from 119.3 to 135.7 digits correct per minute. Student 10’s rate of digits correct during practice increased sharply across the four sessions of the partner-administered time trials condition.

**Student 11.** Student 11 was present for a total of 34 of the 41 sessions. She missed sessions 2, 7, 14, 16, 23, 33, and 34. She was tutored by Student 12. Student 11 participated in baseline during sessions 1 to 38 and partner-administered time trials for sessions 39 to 41.

Figure 1 (sixth tier, left) shows the rate of digits correct during practice by Student 11 during baseline and partner-administered time trials. During baseline, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice by Student 11 averaged 89.8 digits correct per minute, with a range from 83.7 to 97.7 digits correct per minute. During the three sessions in the partner-administered time trial condition, her rate of digits correct during practice showed a rapid increase.
Student 12. Student 12 was present for a total of 32 of the 41 sessions. She missed sessions 2, 3, 7, 14, 16, 20, 31, 32, and 35. She was tutored by Student 11. Student 12 participated in baseline during sessions 1 to 38 and partner-administered time trials for sessions 39 to 41.

Figure 1 (sixth tier, right) shows the rate of digits correct during practice by Student 12 during baseline and partner-administered time trials. In the baseline condition, written practice did not occur. In the partner-administered time trials condition, the rate of digits correct during practice of Student 12 averaged 98.2 digits correct per minute, with a range from 81.0 to 98.0 digits correct per minute. Student 12’s rate of digits correct during practice increased steadily during the three sessions of the partner-administered time trials condition.

Rate of Digits Correct on Complex Multiplication Problems

Figure 2 shows the rate of digits correct and incorrect for each student. Rate of digits correct on the complex multiplication problems will be discussed completely in this section. Rate of digits incorrect, shown in Figure 2 by the open circles, ranged 0 to 9.3 digits incorrect per minute on the complex multiplication problems tests across all students. As the figure shows, trends for rate of digits incorrect were stable across conditions for all students throughout the study, making a complete description of this behavior moot.

Student 1. Figure 2 (upper tier, left) shows Student 1’s rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 1’s rate of digits correct had a mean of 36.3 digits correct per minute, with a range from 30.7 to 42.3 digits correct per minute. In the peer tutoring condition, her rate of digits correct had a mean of
Figure 2. Rate of digits correct and incorrect on complex multiplication problems.
37.0 digits per minute, and ranged from 27.0 to 44.3 digits correct per minute. The mean rate of digits correct on the complex problem test during peer tutoring represents an increase of 0.7 digits correct per minute over rate of digits correct during baseline. During the partner-administered time trials her rate of digits correct had a mean of 43.2 digits per minute, with a range from 31.3 to 57.7 digits correct per minute. Student 1's mean rate of digits correct during partner-administered time trials represents an increase of 6.2 digits per minute over rate of digits correct during peer tutoring. Student 1's rate of digits correct was variable throughout the study, but showed a definite increasing trend during the baseline and partner-administered time trial conditions. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 33.5 digits correct per minute. The last five sessions (time trials) of the study she averaged 50.3 digits correct per minute. This difference represents an increase in rate of 17.6 digits per minute over the course of the study.

Student 2. Figure 2 (upper tier, right) shows Student 2's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. Student 2's rate of digits correct during the baseline condition had a mean of 36.3 digits per minute, with a range from 29.0 to 43.3 digits correct per minute. His rate of digits correct had a mean of 41.7 digits per minute, and ranged from 36.3 to 48.3 digits per minute in the peer tutoring condition. The mean rate of digits correct on the complex problem test during peer tutoring represents an increase of 5.4 digits per minute over rate of digits correct during baseline. During the partner-administered time trials his rate of digits correct had a mean of 40.4, with a range from 34.7 to 44.0 digits correct per minute. Student 2's mean rate of digits correct during partner-administered time trials represents a
decrease of 1.3 digits per minute over rate of digits correct during peer tutoring. Student 2's rate of digits correct was variable throughout the study, but showed variability during baseline. During the peer tutoring condition, Student 2's rate of digits correct increased in level over baseline rates, and continued to be variable. Rate of digits correct for Student 2 had a slightly lower level during partner-administered time trial conditions, and showed a slightly decreasing trend. His rate of digits correct during sessions 1 to 5 (baseline) averaged 39.5 digits correct per minute. The last five sessions (time trials) of the study he averaged 40.7 digits correct per minute. This difference represents an increase in rate of 1.2 digits correct per minute over the course of the study.

Student 3. Figure 2 (second tier, left) shows Student 3's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 3's rate of digits correct had a mean of 38.2 digits correct per minute, with a range from 32.7 to 43.3 digits per minute. In the peer tutoring condition, her rate of digits correct had a mean of 36.0 digits per minute, and ranged from 25.3 to 40.3 digits correct per minute. The mean rate of digits correct on the complex problem test during peer tutoring represents a decrease of 2.2 digits per minute over rate of digits correct during baseline. During the partner-administered time trials her rate of digits correct had a mean of 39.3 digits per minute, with a range from 32.7 to 43.3 digits correct per minute. Student 3's mean rate of digits correct during partner-administered time trials represents an increase of 3.3 digits per minute over rate of digits correct during peer tutoring. Student 3's rate of digits correct was variable throughout the study, and showed a definite increasing trend during the baseline condition. The data were extremely variable during the peer tutoring and partner-
administered time trial conditions. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 35.3 correct digits per minute. The last five sessions (time trials) of the study she averaged 40.6 digits correct per minute. This difference represents an increase in rate of 5.3 digits correct per minute over the course of the study.

**Student 4.** Figure 2 (second tier, right) shows Student 4's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. Student 4's rate of digits correct during baseline had a mean of 29.6 digits correct per minute, with a range from 21.0 to 36.3 digits correct per minute. In the peer tutoring condition, her rate of digits correct had a mean of 31.1 digits per minute, and ranged from 21.7 to 37.0 digits correct per minute. The mean rate of digits correct on the complex problem test during peer tutoring represents an increase of 1.5 digits per minute over rate of digits correct during baseline. During the partner-administered time trials her rate of digits correct had a mean of 34.6 digits per minute, with a range from 26.7 to 39.0 digits correct per minute. Student 4's mean rate of digits correct during partner-administered time trials represents an increase of 3.5 digits per minute over rate of digits correct during peer tutoring. Student 4's rate of digits correct was variable throughout the study, and showed a slightly increasing trend during the baseline condition. The data were variable during the peer tutoring condition. Student 4's rate of digits correct showed a decreasing trend during the partner-administered time trials condition. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 29.3 digits correct per minute. The last five sessions (time trials) of the study she averaged 31.3 digits correct per minute. This
difference represents an increased rate of 2.0 digits correct per minute over the course of the study.

**Student 5.** Figure 2 (third tier, left) shows Student 5's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. Student 5's rate of digits correct during baseline had a mean of 35.3 digits correct per minute, with a range from 20.7 to 46.7 digits correct per minute. During the partner-administered time trials condition, her rate of digits correct had a mean of 40.8 digits per minute, with a range from 30.3 to 47.0 digits correct per minute. The mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents an increase of 5.5 digits per minute over rate of digits correct during baseline. Student 5's rate of digits correct was variable throughout the study. The data were extremely variable during the baseline condition, with some leveling off of the variability toward the end of the baseline condition. Student 5's rate of digits correct showed a higher rate of responding at the beginning of the condition with a decreasing trend toward the end of the partner-administered time trials condition. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 30.8 correct digits per minute. The last five sessions (time trials) of the study she had a mean rate of 37.0 digits correct per minute. This difference represents an increase in rate of 6.2 digits correct per minute over the course of the study.

**Student 6.** Figure 2 (third tier, right) shows Student 6's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. Student 6's average rate of digits correct during baseline was 40.2 digits per minute, with a range from 26.0 to 48.7 digits correct per minute. During the
partner-administered time trials condition, her rate of digits correct had a mean of 47.6 digits per minute, with a range from 40.3 to 56.0 digits correct per minute. The mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents an increase of 7.4 digits per minute over rate of digits correct during baseline. Student 6’s rate of digits correct was variable throughout the study, with an increasing trend throughout. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 37.6 digits correct per minute. The last five sessions (time trials) of the study she had a mean rate of 49.4 digits correct per minute. This difference represents an increase in rate of 11.8 digits correct per minute over the course of the study.

**Student 7.** Figure 2 (fourth tier, left) shows Student 7’s rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 7’s rate of digits correct had a mean of 29.0 correct digits per minute, with a range from 17.0 to 41.7 digits correct per minute. During the partner-administered time trials her rate of digits correct had a mean of 34.4 digits per minute, with a range from 24.0 to 42.0 digits correct per minute. Student 7’s mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents an increase of 5.4 digits per minute over her mean rate of digits correct during baseline. Student 7’s rate of digits correct was extremely variable throughout the study, and showed an increasing trend during the baseline condition. The data were also variable during the partner-administered time trial conditions, but the condition was not implemented long enough to discern a distinct trend. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 28.6 digits correct per minute. The last five sessions (time trials) of the study she averaged 36.6
digits correct per minute. This difference represents an increase in rate of 8.0
digits correct per minute over the course of the study.

**Student 8.** Figure 2 (fourth tier, right) shows Student 8's rate of digits
correct on complex multiplication problems during the daily 3-minute timed test.
In the baseline condition Student 8's mean rate of digits correct was 43.2
correct digits per minute, with a range from 31.7 to 53.7 digits correct per
minute. During the partner-administered time trials her rate of digits correct had
a mean of 47.3 digits per minute, with a range from 42.3 to 52.3 digits correct
per minute. Student 8's mean rate of digits correct on the complex problem test
during the partner-administered time trials condition represents an increase of
4.1 digits per minute over her mean rate of digits correct during baseline.
Student 8's rate of digits correct was extremely variable and showed an
increasing trend during the baseline condition. The data were variable during
the partner-administered time trial conditions. Although the trend seems to be
increasing, a definite trend is not discernible because of the short length of the
condition. Her rate of digits correct during sessions 1 to 5 (baseline) averaged
36.3 digits correct per minute. The last five sessions (time trials) of the study
she averaged 47.4 digits correct per minute. This difference represents an
increased rate of 11.1 digits correct per minute over the course of the study.

**Student 9.** Figure 2 (fifth tier, left) shows Student 9's rate of digits correct
on complex multiplication problems during the daily 3-minute timed test. In the
baseline condition Student 9's rate of digits correct averaged 29.4 correct digits
per minute, with a range from 20.0 to 42.0 digits correct per minute. During the
partner-administered time trials her rate of digits correct had a mean of 86.9
digits per minute, with a range from 24.0 to 33.0 digits correct per minute.
Student 9's mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents a decrease of 1.7 digits per minute over her mean rate of digits correct during baseline. Student 9's rate of digits correct was extremely variable and showed a decreasing trend during the entire study. The data were variable during the partner-administered time trial conditions. Although the trend seems to be decreasing in line with the baseline trend, a definite trend is not discernible because of the short length of the condition. Her rate of digits correct during sessions 1 to 5 (baseline) averaged 29.2 digits correct per minute. The last five sessions (time trials) of the study she averaged 27.7 digits correct per minute. This difference represents a decrease in rate of 1.7 digits correct per minute over the course of the study.

Student 10. Figure 2 (fifth tier, right) shows Student 10's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 10's rate of digits correct averaged 68.8 digits correct per minute, with a range from 48.0 to 84.0 digits correct per minute. During the partner-administered time trials her rate of digits correct had a mean of 68.8 digits per minute, with a range from 64.0 to 73.7 digits correct per minute. Student 10's mean rate of digits correct on the complex problem test showed a stable trend across the baseline and partner-administered time trials conditions. Student 10's rate of digits correct was extremely variable and showed a slightly decreasing trend during the entire study. The data were less variable during the partner-administered time trial conditions. Although the partner-administered time trials condition trend seems to be in line with the baseline trend, a definite trend is not discernible because of the short length of
the condition. Student 10's rate of digits correct during sessions 1 to 5 (baseline) averaged 67.3 digits correct per minute. The last five sessions (time trials) of the study she averaged 68.8 digits correct per minute. This difference represents a decrease in rate of 1.5 digits correct per minute over the course of the study.

Student 11. Figure 2 (sixth tier, left) shows Student 11's rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 11's mean rate of digits correct was 37.6 digits correct per minute, with a range from 18.3 to 53.3 digits correct per minute. During the partner-administered time trials rate of digits correct had a mean of 42.0 digits per minute, with a range from 32.2 to 51.3 digits correct per minute. Student 11's mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents an increase of 4.4 digits per minute over her mean v during baseline. Student 11's rate of digits correct was extremely variable throughout the study. During the baseline condition, two distinct trends appeared. Student 11's rate of digits correct showed a sharply increasing trend across sessions 1 to 14. At session 15, Student 11's rate of digits correct dropped over 20 digits per minute from the mean of the previous six data points. From session 15 to 38, there was an increasing trend, but the rate fluctuated greatly, with seven instances of differences of more than 10 digits per minute between consecutive sessions. The data continued to be variable during the partner-administered time trial conditions. The trend during partner-administered time trials seemed to be increasing, but a definite trend was not discernible because of the short length of the condition. The mean rate of digits correct for Student 11 during sessions 1 to 5 (baseline) was 36.5 digits
correct per minute. The last five sessions (2 baseline and 3 time trials) of the study she averaged 45.3 digits correct per minute. This difference represents an increase in rate of 8.8 digits correct per minute over the course of the study.

**Student 12.** Figure 2 (sixth tier, right) shows Student 12’s rate of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition Student 12’s mean rate of digits correct was 37.3 digits correct per minute, with a range from 24.3 to 52.3 digits correct per minute. During the partner-administered time trials her rate of digits correct had a mean of 41.6 digits per minute, with a range from 39.7 to 43.0 digits correct per minute. Student 12’s mean rate of digits correct on the complex problem test during the partner-administered time trials condition represents an increase of 4.3 digits per minute over her mean rate of digits correct during baseline.

Student 12’s rate of digits correct was extremely variable throughout the study. During the baseline condition, her rate of digits correct showed an increasing trend across sessions 1 to 12, then the rate level dropped and showed a highly variable, increasing trend. The data continued to be variable until the last six sessions, where the rate of digits correct level again dropped, then showed a steady linear, increasing trend. This trend began in the last three baseline sessions and continued through the partner-administered time trial conditions. The mean rate of digits correct for Student 12 during sessions 1 to 5 (baseline) was 34.4 digits correct per minute. The last five sessions (2 baseline and 3 time trials) of the study she averaged 39.8 digits correct per minute. This difference represents an increase in rate of 5.4 digits correct per minute over the course of the study.
**Percentage of Digits Correct on Complex Multiplication Problems**

**Student 1.** Figure 3 (upper tier, left) shows Student 1's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 1's percentage of digits correct averaged 88.2, with a range from a low of 82.2% to a high of 94.4% of digits correct. During tutoring her percentage of digits correct had a mean of 90.2, and ranged from 81.8% to a high of 99.3% of digits correct. In the partner-administered time trial condition, Student 1's percentage of digits correct averaged 92.9, with a range from 83.2% to 98.8% of digits correct. Student 1's percentage of digits correct was quite variable during all conditions. Her percentage of digits correct during the sessions 1 to 5 (baseline) averaged 87.2. During the last five sessions (time trials), her percentage of digits correct increased to 95.9.

**Student 2.** Figure 3 (upper tier, right) shows Student 2's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 2's percentage of digits correct had a mean of 89.0%, with a range from a low of 80.6% to a high of 97.7% of digits correct. During tutoring his percentage of digits correct had a mean of 95.4, and ranged from 92.9% to a high of 100% of digits correct. In the partner-administered time trial condition, Student 2's percentage of digits correct had a mean of 92.8% correct, with a range from 85.2% to 100%. Student 2's percentage of digits correct was quite variable during the baseline and partner-administered time trial conditions. His percentage of digits correct during the peer tutoring condition was quite stable yet showed a slightly decreasing trend. His percentage of digits correct during the sessions 1 to 5 (baseline) averaged
Figure 3. Percentage of digits correct on complex multiplication problems.
91.9% of digits correct. During the last five sessions (time trials), his percentage of digits correct increased to 92.9.

**Student 3.** Figure 3 (second tier, left) shows Student 3's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 3's percentage of digits correct averaged 98.2%, with a range from a low of 94.4% to a high of 100% correct. During tutoring her percentage of digits correct had a mean of 96.1%, and ranged from 90.5% to a high of 100% correct. In the partner-administered time trial condition, Student 3's percentage of digits correct averaged 97.0% correct, with a range from 94.1% to 100%. Student 3's percentage of digits correct was quite stable during the baseline and partner-administered time trials conditions. During peer tutoring, Student 3's percentage of digits correct was the most variable, but fluctuated across only 10 percentage points. Her percentage of digits correct during the sessions 1 to 5 (baseline) averaged 97.9%. During the last five sessions (time trials), her percentage of digits correct rose to 98.4% correct.

**Student 4.** Figure 3 (second tier, right) shows Student 4's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 4's percentage of digits correct averaged 89.9%, with a range from a low of 78.8% to a high of 96.7% correct. During tutoring her percentage of digits correct had a mean of 91.0%, and ranged from 84.8% to a high of 96.2% correct. In the partner-administered time trial condition, Student 4's percentage of digits correct averaged 92.5% correct, with a range from 85.1% to 98.3%. Student 4's percentage of digits correct was extremely variable during all conditions. During baseline and peer tutoring, her
data show an increasing trend. In the partner-administered time trials condition, there is a decreasing trend. Her percentage of digits correct during the sessions 1 to 5 (baseline) averaged 88.6%. During the last five sessions (time trials), her percentage of digits correct remained stable at 88.4% correct.

**Student 5.** Figure 3 (third tier, left) shows Student 5’s percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 5’s mean percentage of digits correct was 92.7%, with a range from a low of 80.8% to a high of 98.9% correct. In the partner-administered time trial condition, her percentage of digits correct averaged 92.1% correct, with a range from 86.7% to 98.1%. Student 5’s percentage of digits correct was extremely variable during the baseline condition, and the trend was decreasing. In the partner-administered time trials condition, there is a steady trend with less variability. Her percentage of digits correct during the sessions 1 to 5 (baseline) averaged 93.7%. During the last five sessions (time trials), her percentage of digits correct remained stable at 92.5% correct.

**Student 6.** Figure 3 (third tier, right) shows Student 6’s percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 6’s mean percentage of digits correct was 98.2%, with a range from a low of 83.9% to a high of 100% correct. In the partner-administered time trial condition, her percentage of digits correct averaged 99.0% correct, with a range from 93.8% to 100% correct. Student 6’s percentage of digits correct was very high and stable throughout the study, with the exception of one data point during baseline. Her percentage of digits correct during the sessions 1 to 6 (baseline) averaged 96.8%. During the last
five sessions (time trials), her percentage of digits correct was showing a decreasing trend, with an average of 99.3% correct.

**Student 7.** Figure 3 (fourth tier, left) shows Student 7's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 7's mean percentage of digits correct was 87.2%, with a range from a low of 82.8% to a high of 100% correct. During the partner-administered time trial condition, Student 7's percentage of digits correct averaged 95.4% correct, with a range from 89.0% to 98.4%. Student 7's percentage of digits correct was quite variable during the baseline, with fluctuations of as many as 13 percentage points between consecutive sessions. During the partner-administered time trials conditions, her percentage of digits correct seemed to be continuing the variable, decreasing trend. Her percentage of digits correct during the sessions 1 to 5 (baseline) averaged 98.8%. During the last five sessions (time trials), her percentage of digits correct dropped to 94.6% correct.

**Student 8.** Figure 3 (fourth tier, right) shows Student 8's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 8's percentage of digits correct averaged 95.7%, with a range from a low of 89.7% to a high of 100% correct. During the partner-administered time trial condition, Student 8's mean percentage of digits correct was 95.6% correct, with a range from 88.4% to 98.4% correct. Student 8's percentage of digits correct was variable throughout the study. During the partner-administered time trials condition, her percentage of digits correct seemed to stabilize after the first data point and showed an increasing trend. Her percentage of digits correct during the sessions 1 to 5
(baseline) averaged 94.0%. During the last five sessions (time trials), her percentage of digits correct dropped to 97.3% correct.

**Student 9.** Figure 3 (fifth tier, left) shows Student 9's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 9's percentage of digits correct averaged 89.2%, with a range from a low of 69.9% to a high of 100% correct. During the partner-administered time trial condition, Student 9's mean percentage of digits correct was 86.9% correct, with a range from 80.0% to 91.9% correct. Student 9's percentage of digits correct was highly variable throughout the study. In the baseline condition, her percentage of digits correct fluctuated as many as 20.1 percentage points on consecutive sessions. It was noted that Student 9's percentage of digits correct increased across the days of the week, with the exception of the last five data points of the condition. During the partner-administered time trials conditions, her percentage of digits correct seemed to show an increasing trend, but a true trend could not be determined due to the short length of the condition. Student 9's percentage of digits correct during the sessions 1 to 5 (baseline) averaged 91.1%. During the last five sessions (time trials), her percentage of digits correct dropped to 86.7% correct.

**Student 10.** Figure 3 (fifth tier, right) shows Student 10's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 10's percentage of digits correct averaged 96.9%, with a range from a low of 92.6% to a high of 100% correct. During the partner-administered time trial condition, Student 10's mean percentage of digits correct was 96.2% correct, with a range from 90.1% to 99.0% correct. Student 10's percentage of digits correct was very steady
throughout the study and showed a slightly decreasing trend. During the partner-administered time trials conditions, her percentage of digits correct seemed to show increasing variability, but a true trend could not be determined due to the short length of the condition. Student 10's percentage of digits correct during the sessions 1 to 5 (baseline) averaged 96.1%. During the last five sessions (time trials), her percentage of digits correct remained steady at 96.2% correct.

**Student 11.** Figure 3 (sixth tier, left) shows Student 11's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 11's mean percentage of digits correct was 96.2%, with a range from a low of 85.3% to a high of 100% correct. During the partner-administered time trial condition, Student 11's percentage of digits correct averaged 91.3% correct, with a range from 88.2% to 94.2% correct. Student 11's percentage of digits correct was fairly steady throughout the study. The baseline condition showed a slightly increasing trend. During the partner-administered time trials condition, her percentage of digits correct showed a decrease in level. The trend of the partner-administered time trials condition could not be determined due to the brevity of the condition. Student 11's mean percentage of digits correct during sessions 1 to 5 (baseline) was 95.4%. During the last five sessions (2 baseline and 3 time trials), her percentage of digits correct averaged 95.6% correct.

**Student 12.** Figure 3 (sixth tier, right) shows Student 12's percentage of digits correct on complex multiplication problems during the daily 3-minute timed test. In the baseline condition, Student 12's mean percentage of digits correct was 93.2%, with a range from a low of 87.7% to a high of 100% correct.
During the partner-administered time trial condition, Student 12's percentage of digits correct averaged 97.7% correct, with a range from 96.9% to 98.5% correct. Student 12's percentage of digits correct was fairly steady throughout the study. The baseline condition showed a slightly increasing trend from sessions 1 to 15, and a decreasing trend from session 15 through the end of the study. During the partner-administered time trials condition, her percentage of digits correct was stable, but because the condition was short, the trend could not be accurately predicted. Student 12's mean percentage of digits correct during sessions 1 to 5 (baseline) was 95.4%. During the last five sessions (2 baseline and 3 time trials), her percentage of digits correct rose slightly to an average of 96.4% correct.

**Overall Effects**

Table 5 shows the mean rate and percentage of digits correct on the complex multiplication problems for each condition of the experiment. Table 6 shows the mean rate and percentage of problems correct on the test of complex multiplication problems across each condition.

**Social Validity Measures**

Social validity was assessed by indexing the students and teachers' satisfaction and practical success of the program. These indices were determined by analysis of the student and teacher opinion questionnaires.

**Student Evaluations**

One and a half weeks after the final session of the study was completed, the experimenter interviewed all of the participants. Before the interviews, the students were told they would be asked a few questions about the math study. The students were interviewed individually in an outdoor courtyard area.
Table 5

Mean Rate and Percentage of Digits Correct on Complex Multiplication Problems for Each Experimental Condition

<table>
<thead>
<tr>
<th>Student</th>
<th>Rate of Digits Correct</th>
<th>Percentage of Digits Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Peer Tutoring</td>
</tr>
<tr>
<td>1</td>
<td>36.3 (10)</td>
<td>37.0 (10)</td>
</tr>
<tr>
<td>2</td>
<td>36.3 (9)</td>
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<td>3</td>
<td>38.2 (15)</td>
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</tr>
<tr>
<td>4</td>
<td>29.6 (14)</td>
<td>31.1 (6)</td>
</tr>
<tr>
<td>5</td>
<td>35.3 (21)</td>
<td>40.8 (13)</td>
</tr>
<tr>
<td>6</td>
<td>40.2 (22)</td>
<td>47.6 (12)</td>
</tr>
<tr>
<td>7</td>
<td>29.0 (27)</td>
<td>34.4 (6)</td>
</tr>
<tr>
<td>8</td>
<td>43.2 (26)</td>
<td>47.3 (6)</td>
</tr>
<tr>
<td>9</td>
<td>29.4 (30)</td>
<td>27.7 (4)</td>
</tr>
<tr>
<td>10</td>
<td>68.8 (33)</td>
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<tr>
<td>11</td>
<td>37.6 (31)</td>
<td>42.0 (3)</td>
</tr>
<tr>
<td>12</td>
<td>37.3 (28)</td>
<td>41.6 (3)</td>
</tr>
<tr>
<td>Grand Mean</td>
<td>39.7 (266)</td>
<td>37.2 (32)</td>
</tr>
</tbody>
</table>

a Numbers within the parenthesis following rate data indicate number of sessions in that condition.
Table 6

Mean Number, Rate, and Percentage of Problems Correct on Complex Problem Tests for Each Experimental Condition

<table>
<thead>
<tr>
<th>Student</th>
<th>Number of Problems Correct</th>
<th>BL</th>
<th>PT</th>
<th>TT</th>
<th>Mean Rate of Problems Correct</th>
<th>Percentage of Problems Correct</th>
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</thead>
<tbody>
<tr>
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<td></td>
<td>BL</td>
<td>PT</td>
<td>TT</td>
<td>BL</td>
<td>PT</td>
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<tr>
<td>1</td>
<td>44/92</td>
<td>85/131</td>
<td>1.5</td>
<td>1.8</td>
<td>2.3</td>
<td>47.8</td>
</tr>
<tr>
<td>2</td>
<td>51/89</td>
<td>95/136</td>
<td>1.9</td>
<td>2.7</td>
<td>2.4</td>
<td>57.3</td>
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<tr>
<td>3</td>
<td>130/141</td>
<td>89/98</td>
<td>2.9</td>
<td>2.5</td>
<td>3.0</td>
<td>92.2</td>
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<td>4</td>
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<td>56.9</td>
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<td>5</td>
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<td>2.5</td>
<td>72.8</td>
<td>70.5</td>
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<tr>
<td>6</td>
<td>205/221</td>
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<td>3.8</td>
<td>92.8</td>
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<td>7</td>
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<td>9</td>
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<td>16/31</td>
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<td>1.3</td>
<td>57.1</td>
<td>51.6</td>
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<tr>
<td>10</td>
<td>463/549</td>
<td>61/73</td>
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<td>5.1</td>
<td>84.3</td>
<td>83.6</td>
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<tr>
<td>11</td>
<td>237/291</td>
<td>23/33</td>
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<td>2.6</td>
<td>81.4</td>
<td>69.7</td>
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<tr>
<td>12</td>
<td>214/252</td>
<td>25/29</td>
<td>2.5</td>
<td>2.8</td>
<td>84.9</td>
<td>86.2</td>
</tr>
<tr>
<td>Total</td>
<td>2113/2708</td>
<td>812/1053</td>
<td>2.6</td>
<td>2.2</td>
<td>2.8</td>
<td>78.0</td>
</tr>
</tbody>
</table>
adjacent to the cafeteria. The experimenter asked questions from the Student Interview Form, and encouraged explanations to statements the students made (see Appendix D).

The questions asked students to: describe the methods used (i.e., Questions 1, 5, and 7), distinguish procedures they liked or disliked (i.e., Questions 2, 3, 4, 6, 8, and 9), determine their views on the effectiveness of the procedures (i.e., Questions 10, and 11), and ascertain practical usefulness of the procedures (i.e., Questions 12, 13, and 14). Question 15 was an open invitation for students to provide other information or opinions concerning the study.

Question 1 asked students to describe the study. All students correctly identified it as a study about multiplication performance. Student 1, 2, and 3 included more specific information about trying to go fast on the tests. Student 1 said it was to determine "how fast and accurate" students were.

Question 2 asked students how they felt about working with a partner. All students liked working with a partner or said that it was fun. Students 2 and 8 also indicated that it was "easier" to practice with a partner than alone. Student 6 said it was "fun" and a "challenge to do your best". Student 11 said "it helped to have someone to point out the mistakes you make right away, so you can do better".

Students were asked to identify the best part of the study in Question 3. Six students indicated that the study helped them to work faster (Students 1, 3, 5, 6, 8, and 12). Student 9 liked the "chance to see yourself improve". Four Students liked "going faster" (Students 3, 4, 6, and 10). Students 1, 4, 7, and 9 said that being able to work with a partner was the best aspect. Two students
(Students 2 and 11) indicated that getting out of study hall to do something else was the best part. Students 7 and 10 also responded to the question identifying a favorite procedure, the 1-minute timings with a partner.

On the other hand, Question 4 asked what aspects the students disliked. Five student said that the 3-minute complex multiplication test was difficult or too long (Students 3, 5, 6, 7, and 11). Student 1 said that the 3-minute timing was hard because it made her "anxious about when the time would be up". Students 2 said that "doing [the study] every day got old". Student 10 said that participating in the study was "a pain some days" when she had homework to finish. Students 4, 8, 9 and 12 did not identify any part they did not like.

Only those students participating in the peer tutoring condition (Students 1, 2, 3, and 4) were asked to answer questions 5 and 6. In Question 5, students were asked to describe the peer tutoring flash card method and in Question 6 to identify likes and dislikes. Student 1 stated that this method helped her improve "on the 3-minute time trial a little bit", but it got "boring doing the same cards over and over". Student 2 had no specific dislikes, thought it "helped with some specific facts," and that it was a "good warm-up to the test". Student 3 said when she used the flash cards she "felt weird, like a little kid", but it "helped some". Student 4 indicated that she got "lots of practice" and it helped her to "go faster on the 3-minute test", but it was "just OK".

When asked to tell about the partner-administered time trials in Question 7, all students were able to describe the procedure. Comments included: "It was like coaching" (Student 1), "It got boring doing it every day" (Student 2), "I liked it better than the flash cards" (Student 3), "I made friends with my partner and we really helped each other" (Student 6), "It was good practice" (Student 9),
and "It was a challenge to go faster" (Student 10). Other more general comments by students indicated this procedure was fun (Student 1, 4, 11, and 12), easy to do (Students 3 and 7), and helped students improve on the test (Students 5 and 8).

Question 8 and 9 related to the timing procedure in the partner-administered time trials condition. All students liked operating the timer. Student 2 said he "loved playing with the timer". When it was their turn to be timed, students said "There was some pressure, but it was easier because I wasn't as worried about the time" (Student 1), "I liked competing against time" (Student 2), "I put pressure on myself to get the page done" (Student 3), "Sometimes it was too noisy and I couldn't work fast" (Student 4), "It was fun when I did better" (Student 5), "It was fun to be the fastest and beat everyone else" (Student 6), "I was competing against myself" (Student 9), "I liked this because I liked seeing how fast I could go" (Student 10), and "I got a little nervous" (Student 11). Students 7, 8, and 12 said being timed was "OK".

Question 10 asked students if and how the interventions affected assignments given in their math class. All students indicated that the practice made the work in math class easier and faster, even when they were not working "just a multiplication problem". Students 3, 8, and 12 were specific in stating that they saw improved rate during both in-class and homework assignments for math. Three students said that the practicing made it easier to remember the answers and they didn't have "to stop and think as much" (Student 2, 3, and 6). Student 9 noticed not only was she faster in completing the assignments, but also made fewer mistakes. Student 12 said that practicing
every day was helpful, and she liked it more than her regular class "where she teaches it fast and then goes to something else".

Question 11 asked if students thought working with a peer was a good way to practice facts. All 12 students agreed that this was a good method. Students comments included: "You get information back that can help you out" (Student 2), "You can see your mistakes faster" (Student 3), "It was nice to help each other" (Student 4), "Yes, it is better than working alone and just using a calculator" (Student 5), "It was good to help each other instead of working alone" (Students 6 and 12), "My partner encouraged me to do my best" (Student 7), and "It was competitive, you could beat them, or your own score" (Student 10).

Question 12 asked students to suggest changes in the program. Student 1 suggested using more than 10 cards for the flash card part, because it "got boring". Student 2 said that it helped to practice the math facts, but added, "the teacher or the partner should make the students write the answer three times if they miss it on the test". Student 3 said flash cards should be eliminated and "you should tell how much time is left during the test". Student 6 wanted to add 30 seconds to the timings because she "wanted to keep going". Student 10 said to "give less time and build up problems, making it harder to advance as you go". Student 11 thought having 5 time trials would help more than the current 3 practice time trials. Other students did not have specific suggestions or said they would not change anything.

Question 13 inquired as to what students did during their regular study hall periods and if participating in the study presented any problems. The students reported a variety of activities in which they engaged during the study
hall period. Eight students reported they usually work on homework or study. Talking was an activity named by two students, even though the study hall was a quiet study hall and permitted no talking. Five students reported that they wrote notes to their friends during study hall. One student said that she read books when she finished her homework. Two students said that they usually "do nothing" in the study hall. When asked to follow up on if this study interfered with their usual study hall behavior, students indicated that it did not. Seven students indicated that the program was a good use of their time (Students 2, 5, 6, 9, 10, and 12).

Question 14 asked specifically if students would use a program like this if it were made available during their study hall. Students 2, 4, 6, and 12 said they would definitely use the peer practice program. Students 1, 9, and 11 said they might participate or they would participate occasionally. Student 5 asked if it was really going to happen and said she "would think about it" if her school ever really offered the program. Students 3, 7, and 8 were not interested in participating again. Student 10 said she would participate again only if the material covered was different, because the "math facts were too easy".

In response to Question 15, an open invitation for suggestions or other comments, only 5 students made responses. "I liked working with my partner," said Student 6. Student 9 said "It felt good to see that you can do it". Student 10 suggested the rules should be cut out before the tests to save time. Student 11 claimed "warming up with the time trials helped me get ready and go faster". Student 12 commented that she really liked the time trials and wished her teacher would use it in math class.
Staff Evaluations

Staff members that worked directly with the students involved in the study were asked to participate in a questionnaire. The staff members that were asked to complete the questionnaire included the study hall teachers and the teacher each student had for mathematics. The questionnaires were distributed to 7 teachers. Four of the teachers taught math classes in which students participating in the study were enrolled. One of the four teachers was also a study hall teacher. He was asked to complete the survey from the perspective of the math teacher. Additionally, two other study hall teachers and the librarian were asked to complete the questionnaire. Of 7 questionnaires distributed, 6 were completed and returned. One teacher did not return the questionnaire, but verbally stated that he saw no difference in the student's performance (Student 8) and didn't have time to fill out the paper.

The questionnaire identified a list of students who had participated in the study and asked the teachers to comment on any noted changes in students' mathematics performances over the course of the study. The survey asked the staff member to compare the math performances and the self-confidence levels of the students involved in the study to the students' previous performances (i.e., Questions 4, 5, 6, 7, and 8). Questions were also asked about the logistics of the study (i.e., Questions 1, 2, 9, and 10) and the teaching curriculum for mathematics (i.e., Question 3).

Question 1 asked if the teacher knew about the study and if so, how did he or she find out. Five teachers were asked by the experimenter for permission to conduct the study during their study hall periods or within their classroom. One math teacher said she was uninformed of the study.
Question 2 asked if any of the students involved in the study had mentioned the study or discussed it with the teacher, and if so, what types of comments did the students make concerning the study. One math teacher and the librarian said that students had mentioned the study in passing. Both reported "positive comments overall", but one student had said participating in the study was boring. One student was reported to say the study was "better than being in study hall."

Question 3 asked the math teachers if they had instructed or assigned students in their math class work on basic multiplication facts or problems complex multiplication problems, such as 385 x 29, since the beginning of the study. The math teacher who taught Refresher Math said that the problem solving assignments (word problems) in the book included complex multiplication problems, and they had been assigned during that time period. The two others indicated they did not directly teach those skills.

Question 4 asked if the teachers noted any changes in math performances of the students. One of the teachers noted Student 6 had gotten better in problem solving. Students 2, 4, and 11 were reported as performing worse now than when the study began, as evidenced by their math grades. The other teachers indicated that no changes were seen.

Questions 5 through 8 asked about individual students in the study. The teachers were asked to complete the information in Questions 5 and 6 for each student, only if the student was in math class. Questions 7 and 8 were to be filled out by all teachers answering the survey.

Question 5 asked to circle the description of the students' performance in finishing work in math class. Choices included: finishes work quickly, works at
an average speed, works slowly. Students 3, 4, and 9 were rated as slow workers. Student 10's math teacher said that she is "usually the first one done". Other students were reported as working at an average speed. One teacher commented that it "depends on the day" for Student 7 and 11.

Question 6 asked if the students completed homework assigned in a timely manner. Two of the math teachers said that their students were required to do math homework and grades depended largely upon its completion. The other teacher said that Student 2 had not turned in the last 4 homework assignments. One teacher said that Student 7's homework was turned in but not done carefully. No other specific comments were written.

In Question 7, teachers were asked to rate, on a scale of low, average, and high, the self-confidence levels of the students. The two study hall teachers did not rate the students on this question. Both teachers responded that they did not know the students well enough to answer the question. The math teachers rated Students 2, 6, 10, and 12 as having high confidence levels, Students 1, 9, and 11 as average, and Students 3, 4, 5, and 7 as having low self-confidence.

Question 8 asked about the students' overall school performance (i.e., study skills, social skills, academic work, etc.) and gave the teachers a choice between low, average, or high. One study hall teacher and the librarian did not fill out this question. The study hall teacher rated only two students, and both were rated lower than the math teachers had rated them. The teachers rated Students 3, 4, 5, 7 and 9 as average to low. Students 2, 10, and 12 were rated as high. Students 1, 6, and 11 were rated as average.
Question 9 asked the teachers if the study had caused any disruptions or problems in their class. A study hall teacher described a minor incident between two students as they returned from the study in the library. The students involved were arguing and slapping at one another. The teacher said they were told to stop or they would be written up and the students went to their seats. The librarian pointed out that some of the students in the study were too loud in the library after the experimenter left. Her comment said, "they were riled up after they worked with you." Another teacher said the students coming and going was "a little disruptive, but nothing intolerable". The three other teachers indicated no problems.

Question 10 asked about the future participation of the teachers, in the same role, in another study, 5 of the 6 teachers said they would do it again. The librarian said the study should take place somewhere other than the library. One study hall teacher commented that he was very happy to allow students to participate, because it meant he had fewer students to supervise. One math teacher wrote that the students in his Refresher Math class were "low math achievers" and could use any math practice they could get.
The present study compared the effects of peer tutoring and partner-administered time trials on the number of multiplication digits solved correctly per minute by the high school students. Further, data were analyzed on rate and percentage of digits correct, the response generality of multiplication facts across time and settings, the response generality of practice of basic multiplication facts to more complex calculation problems, and student and teacher opinions and perceptions of the program. Results relative to each of the research questions are discussed in this chapter. In addition, the chapter will address the limitations of the study, implications for classroom practice, and suggestions for additional research. The final section of the chapter will present a summary of the study.

Research Question One

Will high school students’ fluency on complex multiplication problems change as a function of peer practice on basic multiplication facts?

This study examined the effects basic multiplication fact practice on high school students’ rate and percentage of digits correct on a test of complex multiplication problems. The interventions in this study consisted of two types of fluency drills on basic, single-digit multiplication facts administered by peers: peer tutoring and partner administered time trials.
During baseline conditions, students had an overall mean rate of digits correct of 39.7 digits correct per minute on the complex multiplication problems, with a mean percentage of digits correct of 93.9. Overall, students solved an average of 2.6 problems correctly per minute on the test of complex multiplication problems.

The peer tutoring intervention was implemented for Students 1 and 2 on session 13 and on session 21 for Students 3 and 4. The peer tutoring consisted of a practice of basic multiplication facts prior to the test of complex multiplication problems. During peer tutoring, students were shown flash cards and asked to say and write the answers. In the peer tutoring condition, Students 1, 2, and 4 showed increasing trends for the rate of digits correct during practice, while Student 3 had a stable trend line. They averaged 57.1 rate of digits correct during practice in the peer tutoring condition. During the peer tutoring intervention, the students had a grand mean of 37.2 rate of digits correct on the complex multiplication problems, and a mean of 94.6% of digits written correctly. This represented a grand mean of only 2.2 problems solved correctly per minute on the complex multiplication problems test. These data revealed a mean decrease of 2.5 digits correct per minute, and 0.4 problems correct per minute over baseline. A slight increase of 0.7% of digits correct was seen in the percentage of digits correct on complex multiplication problems.

A partner-administered time trials condition was instituted because a robust change in student performance had not occurred as expected during the peer tutoring condition, even with the increase in rate of digits correct during practice prior to the test of complex problems. Time trials was considered an intervention with visual stimuli and response requirements more similar to what
was presented on the complex multiplication tests. Time trials were implemented across the students on session 29 for Students, 1, 2, 3, 4, 5, and 6; session 35 for Student 7 and 8; session 37 for Students 9 and 10; and session 39 for Students 11 and 12.

When the partner-administered time trials condition was implemented, students had a grand mean rate of digits correct of 40.7 on the test of complex problems. Mean percentage of digits correct on the complex multiplication problems during the time trials condition was 92.1% of digits correctly written. This condition had a grand mean of 2.8 problems solved correctly per minute on the complex multiplication test. These data represent a mean increase in rate of digits correct of 3.5 per minute on the complex multiplication problems over the peer tutoring condition. The mean percentage of digits correct on complex multiplication problems during time trials decreased 2.5% of digits correctly written over the peer tutoring condition. The mean rate of complex problems correct per minute increased during time trials by 0.6 problems correct per minute over peer tutoring.

Overall, the scores for rate of digits correct per minute on complex multiplication problems showed a mean change of 1.0 digit correct per minute across the study. Mean percentage of digits correct on the complex multiplication tests decreased 1.8% of digits correct over the study. The rate of complex multiplication problems correct per minute increased from 2.6 during baseline to 2.8 during time trials, an increased change of 0.2 correct complex multiplication problems per minute. This study showed that over the course of the study on complex multiplication problems, three students (Student 1, 6, and
increased their rate of digits correct, and one student showed increased percentage of digits correct (Student 1).

The results of this study replicate similar findings by Cooke (1983). In Cooke's study with fifth-grade educable mentally retarded students, the results of tests on the response generality of basic multiplication facts to more complex problems (i.e., double-digit multiplication problems) showed that despite improvements on basic multiplication fact tests in both rate and accuracy (percentage of digits correct), on more complex problems none of ten students increased in correct rate, only three students showed improvements in accuracy, and three students maintained their initial high accuracy on double-digit tests. In both the present study and in the study by Cooke, the results suggest that although significant gains in rate and accuracy did not show response generality from basic to more complex problems, timing did not adversely affect performance.

The results for this research question stand in contrast to the findings of Van Houten (1980) with respect to daily measures of students' correct and incorrect rates on long division and complex multiplication problems. In that study, intervention consisted of fluency drills on basic, single-digit multiplication facts. During a fluency drill phase, students increased the number of correct answers per minute and decreased their error rate on long division and complex multiplication problems, even though no direct instruction was applied for these complex problems. Unfortunately, results of response generality similar to those of Van Houten's were not obtained in the present study. Fluency practice on basic skills did not seem to produce a corresponding and robust change in complex multiplication problems.
Specifically, students in this study wrote a total of 5481 correct digits, or had a rate of 57.1 digits correct per minute, while solving basic multiplication facts during peer tutoring practice, but no effect was noted to the complex multiplication problems. During the partner-administered time trials condition, the students wrote a total of 27,131 correct digits during practice, an average rate of 93.6 digits correct per minute, but no effect was noted to the complex multiplication problems. Further, the lack of progress could not be accounted for based on the mode of responses. Previous studies in peer tutoring used oral responses (Cooke et al., 1983), but this study used written responses from the beginning, the same type of responses needed for solving complex multiplication problems on the test. The practice portion of the time trial condition even more closely approximated the stimulus conditions and response requirements of the complex multiplication tests.

**Research Question Two**

Is there a relation between student rate of digits correct during practice and their rate of digits correct on complex multiplication problems?

During baseline conditions, students did not make written responses on basic facts prior to the complex multiplication problems test. During the peer tutoring and partner-administered time trials conditions, all students showed improving trends with respect to the rate of digits correct during the practice portion of the session. The grand mean rate of digits correct during practice in the peer tutoring condition was 57.1. During partner-administered time trials, this rate of digits correct during practice increased for all students to a mean of 93.6 digits correct. This represents an increase of 64% or 36.5 digits correct per minute. Although this change in practice procedures nearly doubled the rate of
digits correct during practice, no subsequent changes were observed in the students' rate or percentage of digits correct on the complex multiplication problems test.

Across the conditions, the grand means for rate of digits correct decreased 2.5 digits per minute from baseline to peer tutoring (39.7 to 37.2 respectively), and rebounded from peer tutoring to time trials by 3.5 digits correct per minute (37.2 to 40.7 respectively). Percentage of digits correct across the students for each condition changed from 93.9% in baseline, improved to 94.6% during the peer tutoring condition, and decreased to 92.1% during the partner-administered time trials condition.

These results are again similar to the findings of Cooke (1983). In her study, students were asked to compute written answers to multiplication facts. This behavior was examined under two conditions, one in which students received reinforcement for accuracy (percentage of digits correct) and in the other, for rate. During the rate condition, students wrote more digits correct per minute on the multiplication fact tests than during the accuracy condition. When students were asked to work for accuracy, they had a higher percentage of digits correct on the multiplication fact tests than in the rate condition.

The present study may have replicated the findings of Cooke through the inadvertent reinforcement of rate or percentage of digits correct through comments, emphasis on scores, and/or the specific procedures themselves. For example, peer tutoring required students to make a correction to errors before moving to the next flash card and time trials emphasized speed but had no provisions for error correction. Results for three of the four students, as well as the grand mean, showed that student performance on the test of complex
multiplication problems during peer tutoring decreased in rate of digits correct and increased in percentage of digits correct. During the partner-administered time trials condition, the grand mean reflected an increase in rate of digits correct and a decrease in percentage of digits correct on complex multiplication problems. The mean changes in rate and percentage of digits correct could also have been a result of variability. In short, changes were not of significant magnitude to make a difference in the lives of the students, even in the situation of the occasional timed mathematical test.

While it could be argued that the students' percentage of digits correct was high throughout the study, fluency of responses must continue to be an important dimension of their academic performance. Fluency (accuracy plus speed) is one of the key ingredients for building the functional use of a skill. Proficient responding is required in many situations, both in and out of school. Finally, fluency is also related to the maintenance and generality of skills (Ivarie, 1986; Stokes & Baer, 1977).

**Research Question Three**

*Will any other staff members in the building notice any changes in student behavior or math performance because of the program?*

The results of the faculty perceptions survey indicated that only those teachers who had been informed of the study by the experimenter knew the study was taking place in the school. Those teachers were contacted because of either their participation as study hall teachers, or their classroom was being used for the study, and received only a brief description of the study. When the teachers were asked to discuss the changes in student performance, one teacher reported that a student improved problem solving skills, a skill not
addressed in the study. Three students were reported as having in-class performance levels that had decreased from pre-experimental levels. None of the teachers reported any improvements related to the skills under investigation.

One explanation for these lack of positive data from the teachers is that they simply reported what the data appeared to show. That is, significant change did not take place. A second explanation is that changes in student performance were not significantly robust to "call attention to themselves." Had the students shown more convincing growth, the teachers' perceptions may have changed as well. Finally, given the training level of the teachers in terms of item analysis, it may be that students made small changes in computing digits per minute, but their graded tests from the mathematics teacher examined other problems. These teachers, like most teachers, made educational decisions based on accuracy information (percentage correct), not information on rate. Hence, limited student improvement was masked by larger levels of failure or by measures lacking the sensitivity to make discriminations between the performance levels.

**Research Question Four**

What are the students' opinions of the math fact peer practice program?

Students were asked 15 questions about their participation in the study. Overall, students had positive comments about the program. When asked specifically if they would participate in a similar program during their study hall period, 9 students indicated they would participate to some extent or showed interest. The remaining 3 students said they were not interested in participating in similar programs.
Students said that the structured practice time was a good use of their study hall period. Students reported they enjoyed being taken out of study hall, except in cases when their homework was not yet complete or they had a test later in the day and wished to study. The students indicated they liked working with a partner and the procedures were fun. Two students made comments about receiving immediate feedback from their partners. Those students said that the tutoring and time trial procedures aided them in the correction of mistakes before they were asked to perform the skill on the complex multiplication problems test.

All of the students responded that the practice of basic facts and complex multiplication problems during the study, resulted in a perceived increase in rate of responding on other mathematics assignments. As evidenced on the basic fact time trials, students did improve in the rate of digits correct during practice. Although no response generality effects were shown in this study, students felt they were able to complete mathematics assignments at a faster rate, without sacrificing the accuracy (percentage correct) of their performance. The students felt good about the improvements they were making. This awareness of rate and the perceived increase in rate on the part of the students could be the "confidence" in their mathematics ability that is one of the general goals set forth in the *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics. Although the students had an increased "confidence" level after participating in the study, the actual performance data on both rate and percentage of digits correct showed little change in the students' performance on the test of complex multiplication problems. As Haughton (1972) reported, motivation is necessary, but not
always sufficient for the development of skill proficiency. Binder (1984) noted that failures to increase skills with motivational procedures may not represent an absence of the reinforcement function, but rather, may involve an absence of adequate "space" beneath the ceiling imposed by comparatively low tool skill frequencies.

**Limitations**

A major limitation of this study relates to the experimenter's inability to readadminister the State of Ohio Mathematics Proficiency Test. This is a state-regulated assessment measure, and was not available for use after data collection. Hence, despite the fact that student performance on basic math fact practice increased--admittedly with no corresponding performance increase in complex calculation--it is uncertain how students would have responded to this test. It should be noted that there is some optimism for believing that their performance on the proficiency test would have improved. Like most assessment devices, if students score well with easier test items, their overall performance would be affected positively. As an example, a raw score of 28 on a given test might yield a grade equivalent score of 4.5, but a raw score 36--just 8 more problems correct--might yield a grade equivalent score of 7.5. Essentially, the students' performance could increase by several grade levels with only minimal improvement in raw score points.

A second limitation relates to the need to institute the conditions for two students simultaneously. The nature of students working in pairs decreased the possible number of verifications and replications in the design. Pairing students to work together, especially during peer tutoring, caused some sessions to be eliminated for students when their partner was not present. Although student
attendance at school was good, field trips and special events often removed students from class and the data session was lost for the pair. Additionally, because students in the peer tutoring intervention were making little or no progress, this intervention was removed in favor of looking for a more robust intervention. This change in procedure led to concurrent changes of the intervention for six students. Eventually, the length of the experiment was too short to determine the effectiveness of the time trial condition for Students 9 through 12.

Third, the variability of student responses was a limiting factor in the study. Although the experimenter extended the baseline conditions, tried to control external variability, and waited for steady state responding, not enough control over multiple variables affecting the performance of the students could be gained. Teachers in classrooms are faced with this control problem every day. This limitation may have been avoided with the addition of contingencies for performance. There were few benefits for the students, since they participated voluntarily and did not receive contingent reinforcement. At the high school level, some students were quite adept at creating unprompted "excuses" for their performance rather than responding at the levels to which they had previously attained. Other students were responsive to the time trials, and worked consistently to achieve a new high score.

Next, the study is limited by the lack of control in the area of verbal praise. Measures of informal praise, prompts, and cues to the students were not taken. A scripted procedural checklist was used daily by the experimenter to ensure consistent administration of the interventions, but the effects of incidental reinforcement from the experimenter, observer, or peers is unknown. As
mentioned above, the procedures themselves may have emphasized and reinforced different behaviors during the different conditions. Peer tutoring may have emphasized percentage of digits correct and partner-administered time trials may have emphasized rate of digits correct. These conditions should be better controlled and measured with respect to their effect on rate and percentage of digits correct.

Methods that require students to repeatedly perform a specified behavior are susceptible to practice effects, the students' ability to perform the behavior improves simply because of the opportunities to practice (Cooper et al., 1983). Although the practice effect is considered a limitation and a confound to experimental research, it is a desired effect in the applied classroom setting, as increases in student performance are the goal. This is especially true during the practice stage of learning. Students that participated in this study were not at the acquisition stage of learning--the first stage of learning, in which students learn how to perform the skill--as indicated by the pre-experimental assessment. During the practice stage of learning, the focus should switch to fluency building. Feedback in the practice stage should emphasize the quantitative aspects of performance--rate. The acceleration in the correct rate of digits written per minute by the students during the peer practice conditions shows a large number of responses that could be made in a short amount of time by the students. This effected increase in responding may been a result of practice, but the goal was to increase the opportunities for responding, and that goal was achieved.

Another limitation was the procedure for evaluation of the assessment test. Although the experimenter evaluated the students' performances on the
assessment test for errors in skills other than multiplication to eliminate students with those skills as the cause for errors, low fluency rates in skills other than multiplication were not measured. An assessment of addition with carrying should have been conducted to eliminate what Binder (1984) described as a "deficit-imposed ceiling." This occurs when "low component skill frequencies impose ceilings on the development of composite skill proficiency" (p. 6). Perhaps many of these students needed to build proficiency in addition or carrying skills, rather than multiplication skills. The student's skill level in a complex multiplication problem is limited by his or her skill level in addition. If the student solved addition with carrying problems at a rate of 25 digits per minute, a multiplication problem with this skill embedded within will not be increased without increasing the addition proficiency also.

Another limitation was the possibility of condition-change interactions. The student may have reacted differentially under one condition due to that individual's exposure to a prior condition (Ulman & Sulzer-Azaroff, 1975). Four students were exposed to basic fact practice using peer tutoring and then changed to the partner-administered time trials. This exposure to peer tutoring could have influenced the students to focus more on percentage of digits correct than rate, as previously discussed. Exposing some students to the partner-administered time trials condition only, with no peer tutoring condition, was a precaution to prevent condition-change interaction.

A lack of maintenance data was another limitation. Sessions ran 10 weeks during the spring of the school year. During this time, several scheduled sessions were canceled due to field trips, shortened class periods, or school-wide activities, such as assemblies and special events. Since these sessions
were lost, the intervention had been changed, and extended sessions under the new intervention took longer than planned, maintenance probes after the experiment's completion were omitted. The study was conducted through the next to the last week of classes for the students. During the remaining 8 days in the remaining 2 weeks, the experimenter was unavailable for the 4 days of classes, and the final 4 days of school students took final examinations. The school principal asked that the study not take place during final examination week. Permission was granted for student interviews to be held during the examination week.

**Implications for Classroom Practice**

Clearly, this study must be replicated before classroom-practice related suggestions could be offered with confidence. Still, one possible avenue to explore with respect to practice with either peer tutoring or time trials practice is to have the students practice the complex problems from the beginning. There is precedence in the field for practicing skills directly (Carnine & Silbert, 1979), and the attempt to increase fluency on complex skills by practicing basic skills might be misplaced. Perhaps by using a changing criterion arrangement, students who do not pass the proficiency tests could be reinforced for increasing the rate with which they improve complex problems alone. Present data seem to indicate that students can solve approximately 2 to 4 problems per minute. Structured and systematic practice might improve this level to 5 to 6 problems per minute. Another alternative may be to examine the tool skill frequencies of the students, and increase skills which must be applied in more complex skills. Haughton (1972) suggested that first grade students with basic skill rates of 80 correct digits per minute (or 40 to 50 problems per minute) or
greater, continue to make progress when advancing to more complex skills and problems. Those students with rates of less than 30 correct digits per minute, have been shown to exhibit rate that gradually decreased across skills. Further investigation into the tool skill rates of the high school students may be necessary to find factors contributing to the lack of response generality.

The impact of using peers for additional practice of skills during a high school study hall period is evidenced in this study. Based on the observation of students administering interventions to peers in this study, students are a viable, cost-effective, mode of delivery of instruction. When asked, students responded favorably to their participation in the study. Students indicated they usually were "just sitting there" and perhaps "writing notes to a friend" during their study hall periods. Few students indicated they used the time for studying or doing homework. Students indicated during the opinion survey that such a program would be beneficial and they would be willing to participate in this type of activity. The engaged instructional time of the school day for these students could be increased by up to 14.3% by adding a peer mediated practice session to the study hall period. This could be a cost-effective alternative for schools struggling with remediation of skills for students at-risk of failure and for schools facing state imposed proficiency levels for students.

Understandably, some teachers fear that using time trials may impair percentage correct and students may become frustrated and feel pressured when they are timed (Miller & Heward, in press). Results from this study show that rates of digits correct for all students improved during the timed practice portion of the interventions, percentage of digits correct did not suffer, and the students enjoyed being timed. Although students did not show response
generality to more complex problems, the rate of correct digits during peer
practice on basic facts which was directly intervened upon did improve
dramatically as a result of the timed practice. In another attempt to make timings
more acceptable, McGreevy (1983) suggested “plain English” be used to
describe fluency-building methods and notations. Language he suggested may
make timing more understandable and less intrusive to the classroom teacher.
For example, instead of the term “time trials” which has a negative connotation,
he suggests “counting periods.” “Errors” are replaced with “learning
opportunities.” Guidelines for implementing time trials in the classroom are
available for additional help (Miller & Heward, in press).

Suggestions for Additional Research

The research questions investigated in this study have important
implications for educators at all levels. It appears from this study that there is
little empirical evidence regarding the importance of high rate performance of
basic mathematics skills on response generality to more complex skills with
high school students. This evidence is needed in order to determine the
importance of establishing high correct rate goals for students. Research in the
area of response generality of response fluency in the basic facts to the rate and
percentage of digits correct of more complex skills has had mixed results
(Cooke, 1983; Van Houten, 1980).

The present study should be replicated with improved methodology.
Specifically, the study could be conducted for a longer period of time with
students who enter the study with low percentage of digits correct. By collecting
data on students as they become proficient on basic facts and at the same time
checking for response generality, it may be possible to establish a target correct
rate at which performance on the complex skill reliably increases as a function of high correct rate on the basic skill.

The direct measurement of supporting skills within the complex problem should be monitored carefully. In this study, "deficit-imposed ceiling effects" that may have imposed rate and percentage of digits correct limitations on the students' performances on complex problems were not fully assessed. Tool skill rates in writing or addition could be factors limiting the response generality of the skills to more complex problems, and should also be examined.

Contingencies of reinforcement for rate performance might be arranged for improved fluency with complex multiplication problems directly. Also, incentives for participating in the program (e.g., graduation credit, credit toward academic grades in math class) might be constructed to avoid the "volunteer" effect associated with this study. Stringent control and monitoring of verbally-administered praise, cues, and prompts would perhaps yield information about performance differences between interventions.

**Summary**

This study was conducted to determine the effects of peer practice on fluency of basic multiplication facts and generality to complex problems by high school students. Peer practice included the use of peer tutoring and time trials. The subjects were selected from of pool of 186 students that had not passed the math portion of the state-mandated proficiency test on two or more attempts. Target students consisted of 11 girls and 1 boy from grades 9 and 10. Each student was enrolled in a mathematics class and a study hall period each day. The study examined (a) correct rate per minute, defined as the number of digits correctly written during the timed test divided by 3 minutes, the time students
had available to work; (b) percentage of digits correct, defined as the number of digits correctly written, divided by the number of digits correctly written plus the number of digits incorrectly written (the total number of digits written through the last problem attempted); (c) student response, defined as a written response to a basic mathematical fact by the student during the practice portion of the interventions. Also, social validity data from teachers and students were evaluated. Experimental conditions included: (a) baseline, a condition of no intervention, (b) reciprocal peer tutoring, a condition in which students and partners took turns as tutors and students, practicing basic multiplication facts for 3-minutes each, and (c) partner-administered time trials, a condition in which students and partners took turns being timed on three 1-minute time trials of basic multiplication facts. The independent variables were applied sequentially to the students. Students were trained in the applied procedures immediately prior to the session in which they were implemented. Results showed improvements in rate of responding during the practice of basic facts in peer tutoring and partner-administered time trial conditions. Results did not show significant effects with respect to the students' performance on complex multiplication problems. Findings and implications were discussed with respect to extant literature.
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Miller, A. D., Hall, S. W., & Heward, W. L. (1992). Effects of sequential 1-minute time trials, with and without inter-trial feedback, on regular and special education students’ fluency with math facts. Manuscript submitted for publication.

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Appendix A: Letter to Parents and Parent Consent Form
Parent/Guardian Consent Form For
Participation in Educational Research

I agree to allow my child to participate in a research study examining the effects of peer tutoring practice on accuracy and proficiency of complex multiplication problem performance. This study will be conducted by Ms. April D. Miller in conjunction with Dr. Timothy E. Heron from the Ohio State University College of Education. The daily math-practice sessions will require approximately 15 to 20 minutes per day for the remainder of the school year. I understand that my child's identity will not be revealed in any publication, document, recording, videotape, photograph, computer storage, or any other form of report developed from this research. Additionally, I understand that I may withdraw my consent for my child's participation at any time.

Name of Student

__________________________________________
Signature of Parent or Guardian

__________________________________________
Ms. April D. Miller, M. A.

__________________________________________
Professor Timothy E. Heron, Ed. D.
Appendix B: Basic and Complex Multiplication Time Trial Test Examples
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<th>Name</th>
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Appendix C: Observer's Recording Form
Procedural Reliability Check

IOAs __________________________ Experimenter __________________________
Date __________________________ Time begins/ends _______________________

1. Students called/prompted to go to work area.
2. Pairs instructed to check folders and prepare to practice.
3. Indicates A or B day.
4. Timing begins.
5. Experimenter circulates among pairs.
6. Switch roles.
9. Call students for time trial.
10. Show students their time trial from previous session
11. Collect time trials from previous session.
12. Pass out new time trial sheets, face down.
13. Say "Don't turn it over until I tell you to do so."
14. "Work as fast as you can and try your best, answering as many
problems correctly as you can in 3 minutes."
15. "Don't worry if you don't finish, there are more problems on the test
than anyone can do in 3 minutes. Just try your best."
16. "Do the problems in order. Do not skip any problems."
17. "Work quickly and carefully to try to get the problems correct."
18. "Stop immediately when the timer beeps. Do not write even one
more digit/number."
19. "Is everyone ready?"
20. "Ready? And Go." Timer started on the word "Go".
21. When timer beeps: "Stop writing." Experimenter prompts those who
do not stop.
22. Elapsed time (from "Go" to first beep of timer.) ____________
23. "Turn in the papers."
24. "Thank you for working with me today. Please return to your study
hall seats."
Appendix D: Student Social Validity Questionnaire Form
Student Opinion Questionnaire

Date ____________________________  Student’s name __________________________

Ask student if you may tape the session. Turn on the tape recorder, and then
tell the student the following: I was trying something new in practicing math with
your group. I would like to ask you some questions about these new ways to
practice. I want you to tell me your feelings about them and be honest. I want to
know how you really feel. O.K.? Ask the student the following questions:

1. Please tell me what this study was about.

2. How did you feel about working with other students, with a partner?

3. What was the best part of the study? Why?

4. What part of the study did you like the least? Why?

5. Tell me about the flash card method you used.

6. What did you like or not like about the flash card method?

7. Tell me about working with a partner on 1-minute timed tests.

8. Did you like being the timer? Why?

9. Did you like being the person who was being timed? Why?

10. Do you think that practicing your facts with a peer had any affect on
    assignments given in math class? How?

11. Do you think working with a peer was a good way to practice facts? Why?

12. What would you change about either tutoring method if you were in charge?
    Why would you change that? How would you change that?

13. What do you usually do during the study hall period? Did participating in this
    study cause any problems for you?

14. If a peer practice program was implemented in your study hall, would it be
    used by you?

15. Is there anything else you would like to tell me about this study or the tutoring
    methods used?
Appendix E: Training Scripts
Script for Peer Tutoring Training

Today, I am going to teach you how I want you to practice basic multiplication facts with a partner. This part of the program is designed to give you lots of review and practice on multiplication facts for a short period of time each day. I'll teach you how to use the folder and the procedures for assisting your partner in practicing.

At the beginning of study hall, I will call some students for practice. If you and your partner are to practice, come directly to this area, find your folder, and prepare to start working. You are to practice the multiplication facts in the folder, each practicing for 3 minutes. This is a timed practice, so please do not start until I ask you to begin. After each student gets a turn to practice, we will take the usual 3-minute timed test on complex multiplication problems. Any questions so far? (Answer questions.)

Let me tell you about the specifics of the program. You will work with a partner for 6 minutes using this folder and the contents of the folder. (Show folder.) The folder is a 9" x 12" colored, 2 pocket portfolio by Duo-Tang. The inside, left pocket is labeled "Materials" and contains 2 black pens, 2-centimeter squared grid paper, and an instruction sheet. The right pocket is labeled "Study", and contains basic multiplication fact flash cards to be studied during the practice session. The purpose of this practice time is to review math skills. You will give your partner lots of chances to review the math facts within a 3 minute time span. Your partner will then give you lots of chances to review the math facts for 3 minutes. When you are finished with the reviewing the math facts return your folder to me, and prepare to take our usual 3-minute time trial
on complex problems. When the time trial is finished, you will return to your regular study hall activities.

If it is a day you are not selected to tutor, you will only take the time trial. I will ask all participants to join the group when it is time for the time trial. You will take a timed trial every day.

Practice Instructions

Today we are going to learn one of the ways to practice multiplication facts. This way to learn is called peer tutoring. In peer tutoring, you will work with a partner. You and your partner will take turns practicing some basic multiplication facts. I have found that students can be very good teachers for each other and I think that you will be very good teachers, too.

When you teach just one person at a time, you are called a tutor. A tutor has an important job to teach their student something. A person that is about your same age is called a peer. Since you will be a teacher to one person, who is about your same age, it is called peer tutoring. In peer tutoring, everyone will get a chance to be a tutor, and everyone will get to be a student, too.

When we begin peer tutoring, you will use this folder to keep all of your tutoring materials together. (Show actual folders to be used.) Each part of the folder is important. On the front of the folder, I have printed your name and the letter A or B. The letter indicates whose turn it is to practice first each day. If I announce it is "A" day, the student with "A" on his/her folder will practice first. We will take turns going first.

The folder has two pockets. You will have 1 pocket for your fact flash cards, and 1 pocket for materials for tutoring, such as pens, grid paper and
instructions. If you ever find that you are missing something, please bring it to my attention before tutoring begins.

Every day, at the end of the tutoring time, we will put the tutoring folders away before the other students enter for the time trial. I will collect the folders and place them back in my tote bag. Please make sure you have written your name and the date on each sheet. When you hand in the folder, make sure that the folder is placed upright. If you don't do this, all of the materials will fall out.

Each day before you begin to practice, I will read the rules to you. These rules are really just reminders to you to go as fast as you can and to encourage your partner to do her best. I will then ask you to get ready to practice. When everyone is ready, I will begin the timer for the 3 minute practice time.

Now we are going to learn how I want you to actually practice the flash cards with your partner. This will be called the "practice time". There will be 2 practice times. Each practice will last for 3 minutes. In one practice you will be the tutor, and in the other practice, you will be the student. During the time that you are the tutor, you will help your student practice his facts, the right way, as many times as possible. It is really important that your student has lots of chances to practice saying and writing each answer.

This is how we will do it. It is "A" day. I will call out, "First practice." When I say "First practice," you will sit facing your partner and prepare your materials for the practice time. From your partner's folder (the one with the "A"), take out the student's words that are in the "Study" pocket. Now, let's try it out. "A day. First practice." (Students get folders and flash cards ready. Help those who need direction. Praise those who are correct.)
When you take your student's facts out of the "Study" pocket, you must hold them up like this. (Demonstrate holding card in one hand.) Do not cover any part of the fact on the card. Orient the card to your student, so he can see the fact. As soon as I say to start, begin to show the facts 1 at a time. The student will look at the fact and say the answer. At the same time, the student will write the answer on the grid paper. You must check the answers to see if it is written and stated correctly. If the answer is right, go on to the next fact. Keep going through the flash cards until the timer rings. Always try to go as fast as you can, but give your partner time to say and write the answers. Now let’s practice this skill. (Practice with guidance where needed to correct tutor mistakes in holding or showing the cards, or student mistakes in writing answers on the grid.)

That is pretty easy. But, what if your student makes a mistake? It is the tutor's job to correct the mistake so that the student can practice the fact the right way. If the student keeps practicing it the wrong way, he is going to say and write the answer the wrong way on the test. If your student makes a mistake, he should put an x on the mistake and then you need to let him try again. It is important for the student to put an x on the mistake. Make sure your partner puts an x on any mistake written on the grid paper. (Show the flash card, "5 x 6.") If the student says "25," you say "Try again." What do you say if the student makes a mistake? "Try again." The student puts an x on 25 and tries again. If he gets it right this time, that's great! You should go on to the next flash card in the stack. But, if he gets it wrong again, you need to tell him the correct answer. You will read the fact that is on the card and provide the answer. Then ask your partner to do it--He should put an x on the second wrong answer, read the fact,
then say and write the answer. Let's practice the whole thing together. Remember, if your student misses the fact, you say, "Try again." When he tries again, if he misses it again, you say, "Say 5 x 6 = 30." Your student will say the fact and then write and say the answer. (Practice skills for correction of errors. Ask students to practice and to pretend to make some errors so their partner will get to practice error correction. If mistakes occur in error correction procedures, demonstrate skills again, and have students practice again.)

Sometimes a student might take a long time thinking about what the answer to the fact. If this happens, the student will not get to practice his facts very many times. If the student takes longer than about 3 seconds, it will count the same as a mistake. You will need to count slowly to yourself, quietly in your head, to 3. If your student doesn't say anything you should tell him to "Try it." (to give your partner another chance). If he still does not know the fact or word, or says something incorrect, tell him the fact and have it repeated. Give example: (8 x 4 is presented, student says and writes 16). You say "try again" (student tries again, says and writes 20). You say " 8 x 4 = 32". (Student must say and write answer.) Do not give clues or prompts, just say "Try again", and after the second error just read the problem and tell the answer. The idea is to give as many chances as possible. Go through the cards as fast as you can, without going so fast that your partner does not have a chance. (Demonstrate.)

After the first tutor has helped his student for 3 minutes, then it will be time to switch. I will say "Second practice." When I say "Second practice," the person who was the student, will be the tutor. The first tutor returns those flash cards to the folder, and the new tutor opens and takes out his/her student's
facts. Now she will help her student practice the facts for 3 minutes. Begin as soon as I say to start so that the student can practice as many times as possible!

Next we are going to learn a very important part of being a tutor or a teacher. When you are teaching it is very important to let the students know how they are doing on their work. The teacher must tell the student when he is right or wrong. We have already learned what to do if a student gets a fact wrong. Now we are going to focus on when the student is right. When the student is doing a really good job, the teacher wants the student to keep it up. The teacher will tell the student about how nicely he is doing. Many words or phrases can be used by a tutor to encourage their student and to help the student keep up the hard work. When a tutor says one of these words to his student after the student gives a right answer, it is called praise. You will give your student a praise statement to let him know that he is doing a good job.

When you praise your student, it is very important to remember that the way that you say the praise statement makes a difference. Listen to me say "Great." (Say "Great" using different voice inflections to show different meanings.) The way you say a word can make the meaning change, so be sure to show your student how you really think he is doing by saying the word in an excited way.

Now, besides praising to help your student to keep up the hard work on getting the facts right, you have to remember that the student needs to practice his facts as many times as possible in the 3-minute practice session. If you praise your student every time he makes a try, it will slow him down. Too much time spent on giving out praise will actually make the student practice less. What I want you to do is to praise your student after every time through the
whole deck. You can quickly praise while you shuffle the deck of fact cards and prepare to continue tutoring. I'll show you what I mean. (Choose student to say the pack of facts. Demonstrate the schedule of praise at the end of the stack as you shuffle the deck.)

There are some other times when you should give your student some praise, too. You may praise your student when he gets a fact that was really hard for him, or when the student has been working extra hard or really fast. Another time to give praise is at the end of every session.

Let's try the whole thing. We will take a few minutes for everyone to practice, while I check how you are doing. Remember, it is very important to get your student to say the facts as many times as possible. Get ready for "First practice. Ready? And. GO!" (Stop. Trade roles. Let everyone have a chance to play both roles, as student and tutor.) Does anyone has any questions about any part of peer tutoring? We will end the session by returning the folders to me. Thank you for working with me.
Instruction Sheet for Peer Tutoring Sessions

1. Make sure all materials are in the folder.
   - 2 black pens
   - grid paper
   - 10 multiplication fact flash cards

2. Note which partner tutors first today.
   - On A days _________ tutors first.
   - On B days _________ tutors first.

3. Wait for instructor to start timer and session.

4. Begin practice as soon as time starts. Correct errors and work for speed.

5. Praise student for correct responses at the end of the deck. Shuffle cards and continue.

6. After 3 minutes, timer will beep, tutor and student switch roles. Be sure to use the correct flash cards!

7. At the end, return all supplies to folder. Return folder to Mrs. Miller.

8. Take time trial. Return to study hall.
Script for Partner Administered Time Trials

Today, I am going to teach you how to administer three 1-minute time trials on the basic multiplication facts to a partner. This part of the program is designed to give you lots of review and practice on multiplication facts for a short period of time each day. I'll teach you how to use the folder and the procedures for assisting your partner in practicing.

At the beginning of study hall, I will call some students for practice. If you and your partner are to practice, come directly to this area, find your folder, and prepare to start working. You are to practice the basic multiplication facts by taking a time trial, each partner practicing for 3 minutes total. This is a timed practice, so we will be learning to accurately operate the timers. After each student practices for 3 minutes, we will take the usual 3-minute timed test on the complex multiplication facts. Any questions so far? (Answer questions.)

Let me tell you about the specifics of the program. You will work with a partner for 6 minutes using this folder and the contents of the folder. (Show folder.) The folder is a 9" x 12" colored, 2 pocket portfolio by Duo-Tang. The inside, left pocket is labeled "Materials" and contains 1 black pen, 1 red pen, and 3 time trial sheets containing basic multiplication facts. The right pocket is labeled "Study", and will contain the basic multiplication fact time trial sheets from the previous day's practice session. On the table in your work area, there will also be a count-down timer, like I have been using each day, for your use in timing your partner.

The purpose of the practice time is to review math skills. You will give your partner lots of chances to review the math facts within a 3 minute time span. Your partner will also give you lots of chances to review the math facts for
3 minutes. When you are finished with the reviewing the math facts, you will select one of the three time trials completed by your partner that day to score. When scoring is complete, return your folder to me, and prepare to take our usual 3-minute time trial on complex problems. When the time trial is finished you will return to your regular study hall activities.

If it is a day you are not selected to work with a partner, you will only take the 3-minute time trial on complex multiplication problems. I will ask all participants to join the group when it is time for that test. You will take the complex problem time trial every day.

Administration of Time Trial Instructions

Today we are going to learn a new way to practice multiplication facts. This way to learn is called time trials. You will work with a partner. You and your partner will take turns practicing some basic multiplication facts. I have found that students can be very good teachers for each other and I think that you will be very good teachers, too.

When we begin the partner work, you will use this folder to keep all of your materials together. (Show actual folders to be used.) Each part of the folder is important. On the front of the folder, I have printed your name and the letter A or B. The letter indicates whose turn it is to practice first each day. If I announce it is "A" day, the students with "A" on their folders will practice first. We will take turns going first.

The folder has two pockets. You will have one for materials for taking time trials, such as pens, 3 or more time trial sheets, and one pocket for your time trial sheets from the previous session. You will also have a timer on your
table for timing your partner. If you ever find that you are missing something, please bring it to my attention before tutoring begins.

Every day, at the end of the partner work period, we will put the folders away before the other students enter for the 3-minute time trial. I will collect the folders and place them back in my tote bag. Please make sure you have written your name and the date on each sheet. When you hand in the folder, make sure that the folder is placed upright. If you don’t do this, all of the materials will fall out.

Now we are going to learn how I want you to actually practice the time trials with your partner. A time trial is a timed period of work. During this time trial, you will be asked to answer correctly as many basic multiplication facts as you can in one minute. Each student will complete three 1-minute time trials during the partner practice portion of our session each day. Each part will last for 1 minute, with partners timing each other. The partners will take turns giving and taking the time trials until each person has taken three time trials. In one part you will be the timer, and in the other part, you will be the student. During the time that you are the tutor, you will encourage your student to practice his facts, the right way, as many times as possible.

This is how we will do it. I will read the rules to you each day. These rules are really just reminders to go fast and to encourage your partner to beat her best score. You will sit facing your partner and prepare your materials for the time trials. If it is "A" day, the partner with the "A" on their folder will take the time trial first. From your folder (the one with the "A"), you will take out the time trial sheets that are in the "Materials" pocket, and put your name and the date on the top of the sheet. When you are ready, your partner will time you. The
person being the timer will give the commands "Ready? And. GO!" At the same instant, the person timing will push the button to start the count-down timer. This is how to start the timer, and this is how you reset (clear) it.

(Students are shown timer operation.) Now, let's practice starting the timers and giving the commands to your partner. Do not actually work on the time trial sheet, but pretend to begin work. (Students get folders and time trial sheets ready. Partners take turns starting and clearing timer. Help those who need direction. Praise those who are correct.)

Now that you know how to use the timer, there are some other parts you need to learn. Sometimes a student might take a long time thinking about what the answer to the fact. If this happens, the student will not get to practice the facts very many times. If the student takes longer than about 3 seconds, you should tell her to go on. Do not give clues or prompts, just say something like "Skip it" or "Keep going". The idea is for your partner to work fast, and thinking about one problem for too long will make her go slower.

Next we are going to learn a very important part of being a tutor or a teacher. When you are teaching it is very important to let the students know how they are doing on their work. The teacher must tell the student when he is right or wrong. We have already learned what to do if a student hesitates too long on a fact. Now we are going to focus on when the student is right. When the student is doing a really good job, the teacher wants the student to keep it up. The teacher will tell the student about how nicely he is doing. Many words or phrases can be used by a tutor to encourage their student and to help the student keep up the hard work. When a tutor says one of these words to his
student after the student gives a right answer, it is called praise. You will give your student a praise statement to let him know that he is doing a good job.

When you are praising your student, it is very important to remember that the way that you say the praise statement makes a difference. Listen to me say "great." (Say "great" using different voice inflections to show different meanings.) The way you say a word can make the meaning change, so be sure to show your student how you really think he is doing by saying the word in an excited way.

Now, besides praising to help your student to keep up the hard work on getting the facts right, you have to remember that the student needs to practice his facts as many times as possible in the 1-minute time trial. If you praise your student every time he makes a try, it will slow him down. Too much time spent on giving out praise will actually make the student practice less. What I want you to do is to praise your student after each completed time trial. You can quickly praise while you switch roles and prepare to take your time trial. I'll show you what I mean. (Demonstrate the schedule of praise at the end of the time trial.)

There are some other times when you should give your student some praise, too. You may praise your student when he gets a fact that was really hard for him, or when the student has been working extra hard or really fast. Another time to give praise is at the end of every session.

The final part of the partner-administered time trials is scoring one of your partner's sheets. We will check one of the papers against the answer key. I will put one set of answer keys on your table. When you and your partner have completed the set of timings, you will each pick one of the time trials just
completed to score. You should randomly pick one of the sheets. To score the sheet, compare each answer written by your partner to the answer given on the answer key. Circle each answer that is incorrect and write the correct answer next to it. Do not make any mark on a correct answer. When you have checked each answer, count the number of correct answers and write that number at the top of the paper. Then count the number of problems tried (correct plus incorrect). Write that number under the number correct, like a fraction. Return the paper to your partner. Remember to praise your partner for hard work or an especially fast time.

Let's try the whole thing. We will take a few minutes for everyone to practice, while I check how you are doing. Remember, it is very important to encourage your partner to go as fast as possible. Get ready for the timings. When you are ready, begin timing your partner. (Stop. Trade roles. Let everyone have a chance to play both roles, as student and timer. Score one paper and record the score.) Does anyone has any questions about any part of the partner-administered time trials? We will end the session by returning the folders to me. Thank you for working with me.