THE EFFECT OF EXPLICIT TIMING ON MATH PERFORMANCE USING

INTERSPERSAL ASSIGNMENTS WITH STUDENTS

WITH MILD/MODERATE DISABILITIES

by

Fangjuan Hou

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Special Education

Approved:

Benjamin Lignugaris/Kraft Major Professor	Darcie L. Peterson Committee Member
Judith M. Holt Committee Member	Timothy A. Slocum Committee Member

Byron R. Burnham
Dean of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2010

ABSTRACT

The Effect of Explicit Timing on Math Performance Using Interspersal Assignments with

Students with Mild/Moderate Disabilities

by

Fangjuan Hou, Master of Science

Utah State University, 2010

Major Professor: Benjamin Lignugaris/Kraft
Department: Special Education and Rehabilitation

Explicit timing and interspersal assignments have been validated as effective

methods to facilitate students' math practice. However, no researchers have explored the

combinative effect of these two methods. In Study 1, we extended the literature by

comparing the effect of explicit timing with interspersal assignments, and interspersal

assignments without timing. Generally, participants' rate of digits correct on easy and

hard addition problems was higher during the explicit timing condition than during the

untimed condition. However, the participants' rate of digits correct decreased after initial

implementation of the explicit timing condition.

Motivation plays a crucial role in maintaining performance levels and helping

students make continuous progress. Preferred reinforcers and setting academic targets

have been widely utilized as active motivational components to increase the likelihood of

a successful strategy in school settings. In Study 2, we employed a brief MSWO

reinforcer assessment to identify individual student's low- and high-preference

reinforcers and examined the effects of explicit timing on interspersed assignments combined with high preference or low preference reinforcers, and setting academic targets. In general, explicit timing combined with preferred reinforcers and academic targets produced a more sustainable effect on participants' rate of digits correct than explicit timing alone. In addition, high-preference reinforcers were more effective than low-preference reinforcers for three of five participants. For two participants, an increasing trend was observed when low preference reinforcers were contingent on meeting academic targets. These results are discussed relative to using preference assessments with students with mild/moderate disabilities.

(94 pages)

DEDICATION

To my parents,

Chengke Hou and Yuzhen Shao

侯成珂　　邵玉珍

for your unconditional love...

慈爱无边……

ACKNOWLEDGMENTS

Looking back over these years, I could not accomplish anything without so many people's help and support. First, I owe my deepest gratitude to Dr. Judith Holt, who provided me with tremendous support throughout my graduate program. I would not be able to grasp the opportunity to further my education without her generous offer. Dr. Holt is the person who opened the door for me to an amazing world.

I am greatly indebted to my committee chair, Dr. Benjamin Lignugaris/Kraft, for his direction of this thesis. He led me from the beginning to the end of the process step by step. Through Dr. Lignugaris-Kraft's guidance, I was enlightened to see the beauty of research with all of its excitement, anticipation, and unpredictability. This thesis would not be possible without his patience, knowledge, wisdom, and exemplary mentoring.

I want to extend thanks to Darcie Peterson, who has been my advisor and served as my committee member since the first day when I enrolled in the special education program. She provided me with continuous support and helped me in countless ways through the entire journey. I would also like to thank Dr. Timothy Slocum for providing valuable insights and suggestions regarding my study. I would especially like to thank Mark Groskreutz for his willingness to share expertise, knowledge, and time when I badly needed help.

My special thanks go to Dr. David Forbush, who started out as my committee chair before he became the director of special education in the Cache County School District. Dr. Forbush took the trouble to walk me through registration procedures and study plans when I first came to USU, not knowing the particulars of studying abroad.

His kindness and thoughtfulness helped me enter into a whole new world with less pain and difficulty.

I would like to thank Mrs. Kayleen Wootton for her assistance in collecting data and offering unlimited help to me implementing my study. My sincerest thanks go to the students who participated in this study and their parents. I could never complete the study without their willingness to participate.

Warm thanks go to Kristine Wengreen, Tamara Soto, Cosette Brunner, and Sharon Melton. Due to their professional and kindly assistance, I have had a much smoother journey studying here than it could have been.

In addition, I want to express heartfelt appreciation to Kay Hansen for providing me with advice, support, and encouragement in times of need. I am deeply grateful to have Chunli He as my friend. She has always had faith in me and has been there for me over the decades.

Finally, I am grateful to my family, my parents, sister, and brother. I genuinely appreciate my parents' unconditional love abounded in my life, which has been a source of motivation for me trying to make the most of my ability.

Fangjuan Hou

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

On the 2007 Trends in International Mathematics and Science Study (TIMSS) report, the average U.S. fourth graders' math score (529) was above the TIMSS scale average (500). While U.S. students' math scores have improved in recent years, U.S. students continue to fall behind their peers in a number of European and Asian countries (Boisseau, 2008). On the 2007 National Assessment of Educational Progress (NAEP), researchers evaluated fourth-graders' understanding of mathematics concepts and their ability to apply mathematics to problem-solving. While the percentage of students scoring at or above *Proficiency* has tripled since 1990, only 39% of students met this criterion in 2007 (Lee, Grigg, & Dion, 2007). Development and demonstration of mathematics competence is an essential educational goal for all students, including those with learning disabilities (Bryant & Bryant, 2008).

According to Bryant's (2005) review of early identification and intervention with students with mathematics learning disabilities, learning disabilities in mathematics is estimated to affect 5% to 8% of school-age children in the United States. These statistics are alarming because students' failure in basic mathematics skills may preclude their comprehension of higher level mathematics concepts (Codding et al., 2007; Gersten & Chard, 1999). The TIMSS results suggest that it is necessary for U.S. students to master more challenging mathematical skills in order to compete in the global marketplace (Riley, 1997).

In a longitudinal study of mathematics competencies, Jordan, Hanich, and Kaplan (2003) compared two groups of students at the end of third grade. One group of students demonstrated low mastery of basic arithmetic combinations (such as, 6 + 9), and the other group had fully mastered basic arithmetic combinations. The researchers investigated these students' development of mathematics competencies on a variety of math tasks arranged from the second to the third grades at four time points. Each student was given seven math tasks presented in the following order: exact calculation of arithmetic combinations (i.e., students could use any method they had to figure out the answer); story problems; matching estimations; place value; calculation principles; and automaticity and fluency of arithmetic combinations (i.e., students were required to answer the problems with a time limit). Except place value, all tasks involved simple addition and subtraction.

The results showed that students who mastered arithmetic combination skills steadily increased their calculation fluency, whereas students who had not mastered arithmetic combinations did not demonstrate adequate progress on calculation fluency over time. Researchers suggest that students who have difficulty retrieving basic arithmetic combinations (Geary, 2004), have more difficulty understanding advanced mathematical concepts and obtaining complex mathematics knowledge (Benner, Allor, & Mooney, 2008; Gersten & Chard, 1999; Gersten, Jordan, & Flojo, 2005; Jordan et al., 2003; Pellegrino & Goldman, 1987; Poncy, Skinner, & Jaspers, 2007). Without fluency on basic arithmetic combinations students often employ inefficient procedural strategies (i.e., counting fingers, or concrete objects) to compute arithmetic combinations, this

makes acquisition of complex mathematics knowledge even more challenging (Gersten et al., 2005). Thus, building fluency in basic mathematical skills is the cornerstone that enables students to grasp advanced mathematics knowledge (Benner et al., 2008; Gersten & Chard, 1999; Pellegrino & Goldman, 1987; Poncy et al., 2007).

The feedback that students receive for their academic performance usually focuses on the accuracy of their responses (Miller, Hall, & Heward, 1995). Although accuracy is an essential measure for proficiency, accuracy alone does not provide a precise picture of one's academic performance. Fluency—the ability to perform a skill accurately and quickly–is an important measure of student's academic performance (Cates & Rhymer, 2006; Miller et al., 1995). There is substantial research suggesting that fluency plays a critical role in students' acquisition of academic success in a variety of domains, such as reading (Cates & Rhymer, 2006; Nichols, Rupley, & Rasinski, 2009; Rasinski, 2000), mathematics (Codding et al., 2007; Gersten & Chard, 1999; Pellegrino & Goldman, 1987; Poncy et al., 2007), writing (Van Houten, Hill, & Parsons, 1975; Van Houten, Morrison, Jarvis, & McDonald, 1974), and even cognitive skills (Fry and Hale's study cited as in Benner, Nelson, Allor, Mooney, & Dai, 2008). In summary, academic fluency enables students to perform basic tasks with little conscious effort so that they can focus attention on more complex tasks (Benner et al., 2008).

One strategy for increasing academic fluency is explicit timing. Explicit timing is a procedure that overtly informs students about a time limit while they are working on an academic assignment (Codding et al., 2007; Rhymer et al., 2002). In most explicit timing interventions students are told after each minute how much of the practice period has

elapsed. In previous studies the effect of explicit timing on increasing response rates was validated across a variety of academic subjects. These include writing (Van Houten et al., 1974, 1975), reading (Cates & Rhymer, 2006; Van Houten et al., 1975), and mathematics (Clark & Rhymer, 2003; Codding et al., 2007; Miller et al., 1995; Rhymer, Henington, Skinner, & Looby, 1999; Rhymer & Morgan, 2005; Rhymer, Skinner, Henington, D'Reaux, & Sims, 1998; Rhymer et al., 2002; Van Houten & Thompson, 1976).

In mathematics, Rhymer et al. (2002) found that explicit timing was useful to increase fluency with easy problems but there was some question about the value of explicit timing with difficult problems. Researchers found that when explicit timing was utilized to practice difficult problems, which either involves multiple steps, or complex procedures, students' response rates were not increased, neither was their accuracy level (Rhymer et al., 2002). In addition, it appears that students' initial level of proficiency influence the effectiveness of explicit timing (Rhymer et al., 1998). For instance, explicit timing results in decreased accuracy levels, when students are initially acquiring a skill (Codding et al., 2007; Rhymer et al., 1998).

Interspersal assignments have proved to be an effective method for practicing difficult math problems. In numerous studies researchers demonstrated that students completed more total problems on interspersal assignments compared to the control assignments while holding the accuracy level consistent (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Robinson & Skinner, 2002; Wildmon, Skinner, Watson, & Garret, 2004). Researchers also found that interspersal assignments have a positive impact on students' academic performance, when they are initially acquiring a skill (Neef, Iwata, & Page,

1980). Findings have revealed that as one of the most effective training approaches, interspersal training enhanced students' performance on challenging cognitive mathematic items, such as mental computation, which requires high levels of sustained attention (Robinson, & Skinner, 2002). Moreover, researchers found that both students and teachers prefer interspersal assignments to explicit timing assignments even though students complete more problems during explicit timing (Rhymer & Morgan, 2005).

There is no research that examines the effect of explicit timing when combined with interspersal assignments. The current study is designed to compare the effect of explicit timing on an interspersed assignment with untimed interspersed assignments. Dependent variables will include the rate of overall digits correct, the percent of digits correct for easy problems, the percent of digits correct for hard problems, and the percent of intervals of classroom on-task behavior.

Research Questions

1. To what extent do students with mild/moderate disabilities have a higher rate of overall digits correct during explicit timing using interspersed assignments than untimed interspersed assignments?

2. To what extent do students with mild/moderate disabilities have higher accuracy of easy and hard problems during explicit timing using interspersed assignments than untimed interspersed assignments?

3. To what extent do students with mild/moderate disabilities have more intervals of classroom on-task behavior during explicit timing using interspersed assignments than during untimed interspersed assignments?

LITERATURE REVIEW

The purpose of this literature review is to examine the available research on

explicit timing and interspersal training. This literature review starts with the initial study

on explicit timing, which was applied to increase the number of words written on writing

behaviors, and then the review extends to the application of explicit timing in

mathematics. In order to find the most effective way to implement explicit timing,

students' initial skill level and the difficulty levels of the materials used in experiments

are discussed. The primary goal of this study is to explore the effect of explicit timing

combined with interspersal assignments on the academic and behavior performance with

students with mild/moderate disabilities, so studies on explicit timing and interspersal

assignments involving students with learning disabilities are specifically discussed.

Research on Explicit Timing

In an early study, Van Houten et al. (1974) examined whether explicit timing,

immediate feedback (self counting of words written), and public posting of highest scores

could increase the writing response rates (number of words written per minute) with

second and fifth-grade general education students. During baseline, the students wrote as

much as possible during a 10-minute period about a topic sentence written on the board.

Importantly, the students were not told they were timed. Following the baseline, explicit

timing, immediate feedback, public posting of the highest score for each student, and

instructions encouraging students to beat their highest scores were implemented during

the intervention conditions. Researchers evaluated number of words written and the

quality of writings, which consisted of five dimensions: (1) mechanical writing skills, such as spelling, grammar, and punctuation, (2) variety of vocabulary, (3) number of ideas, (4) development of ideas, and (5) consistency of the story (Van Houten et al., 1974). The researchers found the number of words and overall quality of the writing were both increased during the intervention conditions. However, it was not possible to determine which intervention component directly increased the writing response rates because explicit timing, feedback, public posting, and encouraging instruction were implemented as a whole intervention package simultaneously. In addition, the researchers did not measure whether participants' general on-task behavior increased as a result of the intervention package.

A follow-up study by Van Houten et al. (1975) was conducted using a reversal design with general education students in two fourth-grade classrooms to assess the relative contribution of explicit timing plus feedback (self counting written words), public posting of scores, and praise on students' writing performance. After obtaining a stable baseline, four intervention conditions were implemented using a reversal design to evaluate the effects: explicit timing + feedback, explicit timing + feedback + public scores, and explicit timing + feedback + public posting scores + praise. In this study, in addition to writing rates, researchers also evaluated students' on-task behavior and students' comments on their own performance. The results revealed that with implementation of each intervention component (i.e., timing + feedback, public posting of scores, and praise), the number of words written for both classes increased. Additionally, increased response rate was positively correlated with increased on-task

behavior and increased positive performance comments, such as, "Hey! I beat my score. How many words did you write? Hey! Look what ___ got, or ___ is the highest" (Van Houten et al., 1974, p. 554). Thus, Van Houten et al. (1975) indicated that each intervention component had contributed to the whole intervention package.

According to previous research (Benner et al., 2008; Gersten & Chard, 1999; Pellegrino & Goldman, 1987; Poncy et al., 2007), one critical variable for producing mathematics competence is developing fluency on mathematics component skills. The National Council of Teachers of Mathematics (NCTM, 2006) emphasized the importance of computational fluency as a focal point of curriculum reform, which is more likely due to the hierarchical nature of mathematics curriculum (Codding et al., 2007; Hudson & Miller, 2006). Additionally, Patton, Cronin, Bassett, and Koppel (1997) stated that mastery of basic mathematics skills is the foundation for successful independent living across a variety of situations, including workplace, postsecondary education settings, and living communities.

During mathematics instruction, Van Houten and Thompson (1976) used an ABAB reversal design to assess the effect of the explicit timing procedure on overall correct rate (the number of problems completed correctly per minute) and accuracy with 20 general education second-grade students with poor academic performance. Throughout the experimental period, students were asked to work for 30 minutes on basic math facts worksheets. During baseline conditions, students were given worksheets with basic math facts and told to complete as many problems as possible. During intervention conditions, students were told they had 30 minutes to complete as many problems as

possible, and were instructed to draw a line after the last problem answered at the end of each 1-minute interval. The results showed that the number of problems completed correctly per minute was increased under explicit timing conditions, and the accuracy remained over 90% in both baseline and intervention conditions. Therefore, explicit timing increased the rate of problems completed without decreasing accuracy.

Miller et al. (1995) systematically replicated Van Houten and Thompson's (1976) study with a multiple treatment reversal design across three conditions: (1) 10-minute work period with next-day feedback (correction and encouraging written comments); (2) seven 1-minute timing trials with 20-second intertrial rest intervals with next-day feedback; and (3) two 1-minute timing trials with immediately teacher-directed feedback, and self-correction. In this study the conditions included 1-minute timings which were similar to previous explicit timing studies because the teacher used a stopwatch to time a series of seven 1-minute timed trials overtly. The 10-minute work period condition, however, is different from the control condition used in previous studies, because in previous studies participants did not know they were timed, while in this study participants knew they were timed, but they did not know how long the work period was and they were not stopped after every 1-minute interval. Two classes of students participated in this study, 23 first grade general education students and 11 students in a self-contained special education classroom, ranging in age from nine to 12.

Dependent variables included correct response rate (number of problems answered correctly per minute), accuracy (percent of problems answered correct) and on-task behavior. A pre-experimental assessment was conducted to determine the types of

math facts that would be used in the study. Math facts that most students answered accurately were included, which increased the likelihood that students had obtained sufficient accuracy levels before implementing the timing procedures. The researchers found that students performed at high correct response rates (number of problems answered correctly per minute) with a high level of accuracy in both the first grade classroom and the special education classroom during both 1-minute timing trials with and without immediate self-correction conditions. However, most students obtained their highest response rates and reached their highest accuracy level during the final timing trial with immediate self-correction. Therefore, explicit timing increases correct response rates and accuracy with general education students as well as students with learning disabilities. Further, immediate self-correction seems to be an effective intervention component paired with explicit timing to increase students' correct response rates. In addition, the results showed that students were on-task more during the explicit timing conditions than during 10-minute work period overall, which suggested explicit timing increased students' on-task behavior.

Rhymer et al. (1998) replicated the Van Houten and Thompson (1976) study with briefer experimental periods with third grade African American students using a multiple baseline design across participants. During each session, students were given four minutes to work problems on assignment sheets containing addition, subtraction, and multiplication problems. The number of problems students completed increased from baseline phases to intervention phases, however, in contrast to previous studies, the percentage of problems completed accurately decreased with the implementation of

explicit timing. The researchers hypothesized the decrease in accuracy was related to students' baseline accuracy levels. To analyze this hypothesis the researchers divided the 36 students into three groups, each group included 12 students based on their baseline accuracy. While mean accuracy levels during explicit timing decreased for the low and medium baseline accuracy groups, there was no change in accuracy for the high baseline group. This research suggests that either a specific contingency for accurate responding may be needed with lower performing students or that the level of accuracy should be considered before implementing explicit timing.

Rhymer et al. (1999) found similar results when they implemented an explicit timing intervention with African American students and Caucasian students in second-grade general education classrooms with 4-minute work periods without timing and four 1-minute explicit timing intervals. Each assignment sheet contained one-digit addition problems and one-digit subtraction problems. Most of the students had acquired the skills necessary to complete each type of problems. During baseline phases, participants were instructed to complete as many problems as possible without skipping any problems while still working accurately. Explicit timing phases were similar to baseline phases except that participants were informed that they would be timed for four minutes at 1-minute interval. Results showed that both African American students and Caucasian students completed more problems during explicit timing phases than baseline phases, and the percentage of problems completed correctly showed no change. Referring to the performance data, all students completed problems with over 80% accuracy in both baseline phases and intervention phases. This finding verified the hypothesis made by

Rhymer et al. (1998) that the explicit timing procedure increased problem completion rates without reducing computation accuracy levels for the high baseline accuracy group.

Rhymer et al. (2002) also examined whether explicit timing was as effective with complex math tasks as with simple math tasks with students with mixed abilities in three sixth grade general education classrooms. The researchers used three types of work sheets presenting three different levels of math problems ranging from easy (1 digit plus 1 digit addition), to medium (3 digits minus 3 digits subtraction), then to difficult (3 digits times 3 digits multiplication). Response rate and accuracy were the dependent variables in this study. During baseline, participants were told to work as many problems correct as they could without skipping. The researchers timed covertly for 3-minutes. Intervention phases were identical to the baseline phases except students were told they were timed for a total three minutes at 1-minute intervals. The results showed that students completed significantly more problems per minute on both easy and medium assignments during the explicit timing condition than covert timing condition. However, students did not perform better on the difficult assignment during the explicit timing condition. Accuracy was generally the same across both conditions on all three types of assignments. Therefore, explicit timing was effective on easy and medium mathematics tasks, which only require declarative knowledge or fewer steps to complete. However, explicit timing was not effective on the difficult tasks, such as, 3 digits times 3 digits, or complex word problems, which involve more computational steps or procedures to solve. The results suggest that explicit timing would be considered as an effective

intervention method when the academic task involves simple steps versus complex steps (Rhymer et al., 2002).

Research on Interspersal Assignments

Another treatment that has been prevalently applied to mathematics to increase response rates and facilitate practicing difficult problems is an interspersal intervention (Clark & Rhymer, 2003; Rhymer & Morgan, 2005). It involves placing easy, simple problems among difficult, complex problems (Rhymer & Morgan, 2005). Previous studies on interspersal intervention have shown that interspersing brief and simple items among difficult problems increased students' problem completion rates without reducing response rates and accuracy level of target problems (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins, Skinner, & Oliver, 2005; Neef et al., 1980; Robinson & Skinner, 2002; Wildmon et al., 2004). Researchers theorize that interspersing difficult problems among easy problems is effective because each problem serves as a discrete conditioned reinforcing event towards task completion (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins et al., 2005; Neef et al., 1980; Robinson & Skinner, 2002; Wildmon et al., 2004). During interspersal assignments, students complete more problems because easy problems are completed quicker and with less effort than difficult problems. This provides a higher reinforcement rate toward task completion than if students work on difficult problems alone, thereby enhancing students' attention to academic tasks and improving their performance (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins et al., 2005; Neef et al., 1980; Robinson & Skinner, 2002; Wildmon et al., 2004). In recent research, students rated interspersal assignments less difficult, and requiring less effort

and time, even though they completed more total problems with interspersal assignments (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Robinson & Skinner, 2002; Wildmon et al., 2004).

Most students with mathematics learning disabilities often have computation skill deficits (Jordon et al., 2003), in order to remedy their deficits they need more response opportunities compared to their general education peers. However, students with learning disabilities always feel unrewarded and even frustrated while working on time-consuming and high demand computation problems. Therefore, even though they were provided with many response opportunities, they usually do not choose to actively engage in academic activities (Wildmon et al., 2004). Fortunately, interspersal assignments are an efficient alternate academic assignment structure for students with learning disabilities, which increases students' positive perception of assignments without necessarily decreasing task demand (Wildmon et al., 2004).

Wildmon et al. (2004) employed a within-subjects design to investigate whether interspersing additional simple problems would affect assignment choice and assignment preference among middle-school students with learning disabilities. Experimental assignments contained 15 four-digit subtraction problems and with five one-digit subtraction problems interspersed following every third target problems. Control assignments included 15 four-digit minus four-digit problems which served as target problems. During the experiment, each student was given a four-page packet including both control and experimental assignments, and they were allowed to work on each type of assignment for six minutes respectively. The researchers examined the total number of

problems completed, the number of target problems completed, and the percentage of target problems completed accurately. In addition, each student filled out a questionnaire to rate the perception of difficulty, time and effort for each type of assignment, and then select one format as their homework. The results showed students completed significantly more total problems on the experimental assignment than the control assignment, but no apparent differences were found for the number of target problems completed or the percentage of target problems completed accurately across control and experiment assignments. However, the results of the questionnaire suggested significantly more students rated interspersal assignments as less difficult, and require less time and effort to complete than the control assignments. Thus, this study supported the discrete task completion hypothesis (Skinner, 2002), and suggests that an additive interspersal assignment is an efficient procedure that facilitates active engagement in high demand academic behavior with students with learning disabilities.

Explicit timing and interspersal intervention both produce notable positive impacts on students' mathematics performance, Rhymer and Morgan (2005) employed a within-groups design utilizing third-grade general education students to compare the effects of the explicit timing intervention with an interspersal intervention. Dependent variables included the number of total problems completed, number of target problems completed, and accuracy (percent of problems correct).

The researchers used three trials with nine sheets of math fact problems, including three control assignments, three explicit timing assignments, and three interspersal assignments. Both control assignments and explicit timing assignments respectively

consisted of 96, 2 digit minus 2 digit, subtraction problems requiring borrowing in the ones column (e.g., 62 - 18). While the three interspersal assignments consisted of 72, 2 digit minus 2 digit, subtraction problems, and 24, 1 digit minus 1 digit, subtraction problems placed after every three 2 digit minus 2 digit problems. After the participants completed three different control assignments for three minutes per assignment without being told of a time limit, the participants completed the explicit timing and interspersal assignments for three trials. Each trial consisted of an explicit timing assignment, an interspersal assignment, and a preference survey. In addition, the students and the four teachers in the study completed a treatment acceptability survey for the explicit timing procedure and for the interspersal procedure.

The students completed more target problems (2 digit minus 2 digit) during the explicit timing condition than during the interspersal condition for all trials. Students increased the total number of problems completed during both explicit timing and interspersal conditions compared to the control condition. However, accuracy (percent of problems correct) appeared to decrease across three trials for both interventions, which was likely due to participants' fatigue because of completing three trials in a row (Rhymer & Morgan, 2005). For all trials, students preferred the interspersal assignment and noted that explicit timing was more difficult and required more effort than the interspersal assignments. The teachers also preferred the interspersal assignments and indicated that interspersal assignments are a good way to practice math, and appropriate for students with mixed abilities.

Taken together, both explicit timing and interspersal training are empirically validated interventions to increase math problem response rates of the completion of math problems with a variety range of populations including students with learning disabilities. However, explicit timing appears to be more effective when students have reached certain accuracy level while working on easy problems. In the majority of studies researchers suggest that interspersal assignments enhance academic performance on difficult problems with students even in a low stage of skill level. In addition, students rate interspersal assignments as their preferred homework format.

There is no research in which explicit timing is combined with interspersal assignments. The current study is designed to compare the effect of explicit timing on an interspersal math assignment with an untimed interspersal math assignment. In this study, several dependent variables will be assessed, including the rate of overall digits correct, the percent of digits correct for easy problems, the percent of digits correct for hard problems, and the percent of intervals for on-task behavior.

METHOD

Participants and Settings

Five students ranged from the third grade to the fifth grade participated in this study. All the participants performed below grade level and attended math classes in the resource room. Each participant was classified with a disability as defined by the Individuals with Disabilities Education Act (IDEA), and all participants had current Individual Education Plan's (IEP's). Each participant's age, ethnic, gender and disability classification are presented in Table 1.

This study was conducted in a resource room located at a public elementary school in Cache County School District in Utah. Each session took place at the beginning of math class Monday through Friday. The participants were seated around a curved table facing the experimenter. The participants were engaged for 15 to 20

Table 1

Participant Demographics

Participant	Age	Grade	Ethnic	Gender	Classification
Bill	9	3rd	Caucasian	Male	Communication Disorder
Mike	9	4th	Caucasian	Male	Communication Disorder
Nancy	10	5th	Caucasian	Female	Specific Learning Disabilities
Lynn	11	5th	Caucasian	Female	Specific Learning Disabilities
Remy	11	5th	Caucasian	Male	Multiple Disabilities

minutes for each experimental session. All sessions occurred during the participants'
regularly scheduled resource room math class.

Materials

Pretest packets

Pretest worksheets were selected from Morningside Mathematics Fluency
(Johnson & Morningside Academy, 2007) cumulative math facts worksheets.
Mathematics Fluency teaches math facts by using math fact families, which minimize the
necessary memorization when learning math facts (Johnson & Morningside Academy,
2007). A math fact family consists of a set of math facts which are made from three
related numbers, just as people are related in a family. For example, there are four
addition-subtraction facts in the family 2, 3, 5. They are 2+3=5, 3+2=5, 5-2=3 and 5-3=2.
Cumulative worksheets contain a series of worksheets with sequential difficulty scales,
ranging from *Cum 1 & 2 Add Sub (which includes math fact families 0, 1, all digits)* to
Cum 12 – 16 Add Sub (which includes math fact families 5, 5, 10 to 9, 9, 18), and the first
eleven sets of worksheets, *Cum 1 & 2 Add Sub (which includes math fact families 0, 1, all
digits)* to *Cum 8 – 12 Add Sub (which includes math fact families 3, 7, 10 to 5, 7, 12)* had
been used in the pretest session. Each pretest packet included four worksheets from the
same difficulty level. Each of the worksheets contained 100 math facts arranged in 10
rows with 10 problems on each row. The problems were presented in vertical format.

Interspersal assignments

The experimenter constructed ten different worksheets for each individual participant, from which the interspersal assignments were selected randomly throughout experimental sessions. Each assignment packet consisted of four stapled worksheets, each of which contained 50 math problems mixed with 25 hard problems and 25 easy problems. Five hard problems were randomly placed within every two rows among five easy problems. The first worksheet in each packet always started with three easy problems. All problems were presented in a vertical format.

Dependent Variables

Dependent variables for this study include the rate of overall digits correct, the percent of digits correct for easy problems, and the percent of digits correct for hard problems. In addition, data also were collected on the percent of intervals for on-task behavior under each condition.

The overall digits correct per minute were calculated by dividing the total digits correct of easy and hard problems by the total minutes for each session. The percent of digit correct for easy problems was calculated by dividing the total digits correct by the total digits completed and multiplying by 100%. The percent of digits correct for hard problems was calculated in the same manner as for the easy problems.

Another dependent variable is on-task behavior. On-task behavior occurred, when students sat in their seats quietly, pencils in hands writing answers on the worksheets, or eyes on their own worksheets trying to figure out the answer. All other

behavior (such as, eyes on other students' worksheet, talking out, out of seat, playing with pencils) were considered off-task.

On-task behavior was recorded for each student using a momentary time sampling method with 10-second intervals. A tactile cuing device (a Motive Aider) was used to prompt the experimenter to record on-task behavior. The experimenter recorded on-task behavior for each student sequentially, when the Motive Aider vibrated for each interval. Each student was observed for a total of 20 intervals during each condition of experimental session. The experimenter marked a " | " for on-task behavior and a "O" for off-task behavior on a formatted recording sheet. (See Appendix A for on-task behavior recording sheet.)

Independent Variables

In each experimental session, the experimenter administered untimed interspersed assignments and explicit timed interspersed assignments alternately. Interspersed assignments were provided to students in assignment packets.

During untimed interspersed assignments, students were given a packet of practice problems and told to work on them without an informed time limit. During explicit timing, students worked on the math packet instructed in the same manner as during the untimed condition. However, they were told to work on packets for four minutes and to stop at the end of each 1-minute interval.

After both conditions were implemented, a self-correction procedure was implemented. Students were given an answer key to the practice packets, a colored pen,

and were told to correct their packets independently. When students found an incorrect answer to a problem, they crossed out the incorrect answer and wrote the correct answer. Followed by self-correction, students worked with a partner to practice the problems they missed. Each student stated the problems and correct answers out loud for one minute, and then partners switched roles.

Students then turned in their practice packets. No information was provided comparing the number of problems during each condition. Students just received general feedback such as, "Thank you for working hard." The experimenter checked students' self-correction results and recorded students' scores on a separate recording sheet afterwards.

Experimental Design

An alternating treatments design (Cooper, Heron, & Heward, 2007) was employed to compare the effects of untimed interspersed assignments with explicitly timed interspersed assignments on the performance of easy and hard arithmetic combinations and on-task behavior with students who have mild/moderate disabilities. This design was selected because it can be used to assess the effect of an intervention quickly. In an alternating treatment, two or more independent variables are alternately implemented, which effectively avoids confounding caused by sequence effects.

This study consisted of experimental sessions in which two experimental conditions—explicit timing and untimed practice— were implemented alternately. The order of experimental conditions was counterbalanced across sessions by tossing a coin

prior to every other session. If one condition was implemented first on the current session, it would be implemented secondly on the following session.

Pretest

Students who met the participation requirements had a series of pretest sessions to determine easy problems and hard problems for each participant. On the first day of the pretest, the experimenter instructed students to work on the problems from the left to the right across rows of problems, and to continue to work on the next page without stopping. For the first five days, two pretest packets were administered each day and one packet was administered on the last pretest sessions. The participants were allowed four minutes to work on each packet; however, the participants were not informed they were timed. No feedback was provided on the problems completed. Every participant was given one penny for working on each packet which they might spend in the "classroom store" to exchange for their favorite items on the last Friday of each month, other than that, there was no additional reinforcer delivered.

Easy problems and hard problems were selected for each participant based on the correct digits per minute during the pretest sessions. Only problems that participants scored with at least 90% accuracy were used during the experimental sessions. For each individual participant, there must be a noticeable separation on digits correct per minute between easy and hard problems. In this study, the difference between easy and hard problems was at least 9.5 digits correct per minute for each individual (see Table 2).

Table 2

Easy and Hard Problems for Participants

Name	Problem Type	Description	Digit Correct/Min	Ratio Hard/Easy	Accuracy
Bill	Easy	Add – Subtract 0 1 (All digits), 2 2 4, 2 3 5, 2 4 6, 2 5 7, 2 6 8	17.5		98%
	Hard	Add-Subtract 2 7 9, 2 8 10, 2 9 11, 3 3 6, 3 4 7, 3 5 8, 3 6 9, 3 7 10, 3 8 11, 3 9 12, 4 4 8, 4 5 9	8.0	46%	100%
Mike	Easy	Add-Subtract 0 1 (All digits), 2 2 4, 2 3 5, 2 4 6	23.8		99%
	Hard	Add-Subtract 3 5 8, 3 6 9, 3 7 10, 3 8 11, 3 9 12, 4 4 8, 4 5 9, 4 6 10, 4 7 11, 4 8 12, 4 9 13, 5 5 10, 5 6 11, 5 7 12	13.2	55%	97%
Nancy	Easy	Add – Subtract 0 1 (All digits), 2 2 4, 2 3 5, 2 4 6, 2 5 7, 2 6 8	15.1		95%
	Hard	Add-Subtract 2 9 11, 3 3 6, 3 4 7, 3 5 8, 3 6 9, 3 7 10, 3 8 11, 3 9 12, 4 4 8, 4 5 9, 4 6 10, 4 7 11, 4 8 12, 4 9 13	3.9	26%	100%
Lynn	Easy	Add – Subtract 0 1 (All digits), 2 2 4, 2 3 5, 2 4 6, 2 5 7, 2 6 8	32.4		99%
	Hard	Add-Subtract 2 9 11, 3 3 6, 3 4 7, 3 5 8, 3 6 9, 3 7 10, 3 8 11, 3 9 12, 4 4 8, 4 5 9, 4 6 10, 4 7 11, 4 8 12, 4 9 13	20.5	63%	96%
Remy	Easy	Add – Subtract 0 1 (All digits), 2 2 4, 2 3 5, 2 4 6, 2 5 7, 2 6 8	26.4		98%
	Hard	Add-Subtract 3 5 8, 3 6 9, 3 7 10, 3 8 11, 3 9 12, 4 4 8, 4 5 9, 4 6 10, 4 7 11, 4 8 12, 4 9 13, 5 5 10, 5 6 11, 5 7 12	15.1	57%	98%

Experimental Session

Each experimental session included two conditions, interspersed untimed practice and interspersed explicit timing, and a self-correction procedure. During untimed practice, packets were delivered to each student and they were told: (a) to start when the experimenter says "please start", (b) to work hard and try their best to answer as many problems as they can, (c) not to skip any problems, (d) to work carefully and try to get the problems correct. In addition, students were also told to go to the next page and continue working when they finished one page. Finally, participants stopped writing and put a line after the last problem they finished when the experimenter said "please stop". Also the experimenter told the students not to worry if they could not answer all of the problems, because there were many more problems in the packet than anyone of them could finish. The experimenter timed the participants for four minutes covertly with a digital wrist watch.

The explicit timing condition was similar to the untimed condition, except the experimenter told the students that they would work on the packet of problems for four minutes. After each minute they were told to stop and drew a line after the last problem they finished. (See Appendix B for statement for untimed and explicit timing conditions for Study 1.) The experimenter used an audio timer to time students' performance under this condition. After completing both conditions, students were given their self correction packets and a colored pen to complete their assignment correction routine.

Interscorer Agreement

The experimenter scored all the packets initially. To obtain interscorer agreement data, approximately 33% of the packets were randomly selected to be rescored by a second scorer independently. Percentage of interscorer agreement for each packet was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Across packets, interscorer agreement scores ranged from 99% to 100% with an average of 100% for both the rate of overall digits correct and accuracy of easy and hard problems.

The experimenter was the initial observer for on-task behavior. A trained second observer independently observed on-task behavior using the same manner the experimenter used on 20% of sessions. The interobserver agreement percentage was calculated by dividing the total number of times that the two observers agree by the number of times agree plus disagree and multiplying by 100%. Across participants, interobserver agreement averaged 98% with a range of 85% to 100% for on-task behavior.

Treatment Integrity

Treatment integrity was assessed by an independent observer during 21% of the sessions. The observer used a checklist created by the experimenter to collect data on whether the experimenter appropriately implemented all the steps on the checklist. (See Appendix C for checklist for experimental procedures.) The treatment integrity was calculated by dividing the number of steps checked by the total steps listed and multiplying by 100%. Across the sessions, the treatment integrity was 100%.

RESULT

Rate of Overall Digits Correct

The results of each participant's rate of overall digits correct per minute on both conditions are presented in Figures 1 to 5. Bill averaged 9.3 digits correct per minute with a range of 7.5 to 10.3 digits correct per minute under the untimed condition, while he averaged 12.8 digits correct per minute with a range of 10.3 to 16.3 digits correct under the explicit timing condition. It is clear that the rate of digits correct under explicit timing exceeded the rate of digits correct during the untimed condition throughout the experimental sessions. However, explicit timing produced a decreasing data path in the first three sessions, and then remained level for the following three sessions.

Remy averaged 16.7 digits correct per minute with a range of 14.8 to 18.5 digits correct per minute under the untimed condition, while his average rate of digits correct increased to 20.7 with a range of 16.0 to 25.3 digits correct under the explicit timing condition. Similar to Bill, Remy had a higher rate of digits correct per minute during the explicit timing condition than during the untimed condition in all sessions. In addition, he also produced a noticeable downward trend in the first three sessions during explicit timing. Remy's performance then remained stable for the rest of sessions, but with a little more variability compared to Bill's data path.

Mike averaged 15.3 digits correct per minute with a range of 12.0 to 16.8 digits correct per minute under the untimed condition, while he averaged 17.3 digits correct per minute with a range of 14.5 to 19.3 digits correct per minute under the explicit timing

condition. The rate of digits correct during explicit timing exceeded the rate during the untimed condition on four of six sessions. Mike's data pattern during explicit timing was similar to Bill's and Remy's, a decreasing rate of digits correct per minute in the first three sessions, followed by relatively stable performance.

Lynn's rate of digits correct per minute during explicit timing was higher than her rate of digits correct during untimed sessions on only two of five sessions. However, her average rate of digits correct per minute under the explicit timing condition was slightly higher than her average rate of digits correct during the untimed condition. She averaged 24.9 digits correct per minute with a range of 18.8 to 32.8 digits correct per minute under the explicit timing condition and she averaged 23.8 digits correct per minute with a range of 19.3 to 29.5 digits correcct per minute under the untimed practice condition. There are two noteworthy trends for Lynn. First, similar to Bill, Mike and Remy's data, Lynn produced a clearly initial separation in rate of digits correct per minute in sessions 1 and 2 that favored the explicit timing condition. Second, Lynn's performance during the explicit timing condition continued to decrease. In contrast, her performance during the untimed practice condition increased in sessions 3 and 4 and exceeded her perfomance during the explicit timing condition.

Nancy averaged 11.3 digits correct per minute with a range of 9.0 to 13.3 digits correct per minute during the untimed condition, while she averaged 12.0 digits correct per minute with a range of 9.5 to 14.8 digits correct per minute under the explicit timing condition. Figure 3 shows that the rate of digits correct per minute during the explicit
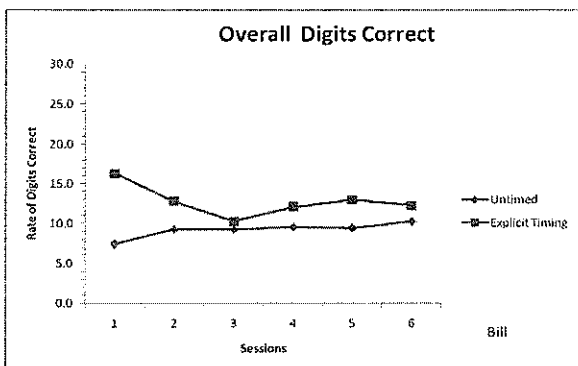
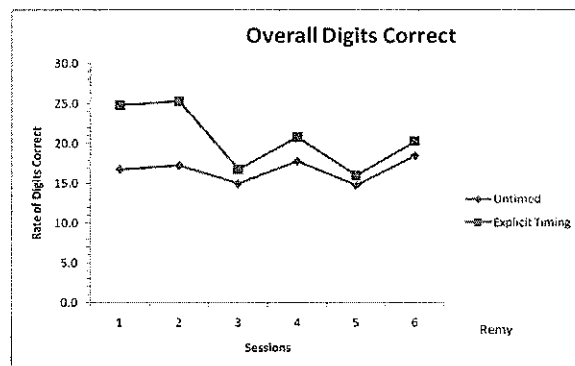*Figure 1.* Rate of overall digits correct for Bill.

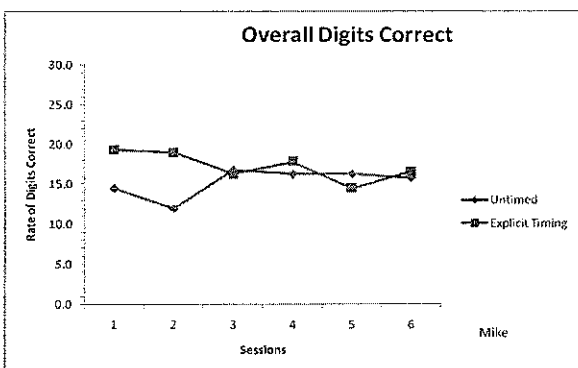*Figure 2.* Rate of overall digit correct for Remy.

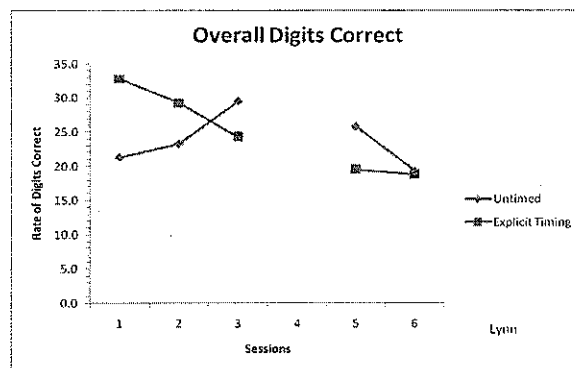*Figure 3.* Rate of overall digit correct for Mike.

Figure 4. Rate of overall digit correct for Lynn.
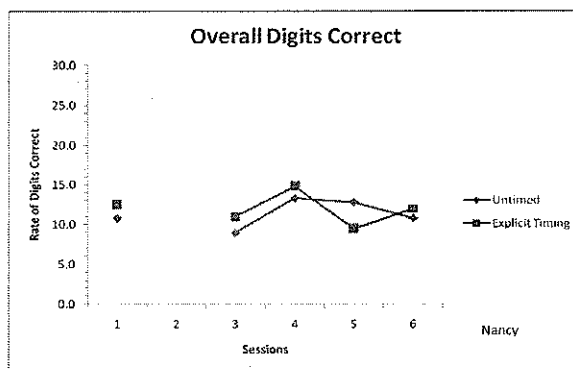
Figure 5. Rate of overall digit correct for Nancy.

timing condition exceeded the untimed condition on four of five sessions. By examining the data path, Nancy is the only participant who did not produce an appreciable initial effect when explicit timing was implemented. Additionally, she produced a relatively stable but with a slightly decreasing data path during explicit timing.

Percent of Digits Correct for Easy and Hard Problems

Given that all participants scored greater than 90% correct on easy and hard problems during the pretest, it was expected that they would also score greater than 90% correct during all untimed experimental sessions. In addition, it is likely that participants would score higher than 90% correct during the explicit timing. Table 3 presents data on the number of sessions during the untimed practice condition and the explicit timing condition when participants exceeded the 90% criteria.

Table 3

Accuracy of Easy and Hard Problems

	Easy Problems Accuracy > 90%		Hard Problems Accuracy > 90%	
Name	Untimed	Explicit Timing	Untimed	Explicit Timing
Bill	5/6	6/6	3/6	1/6
Mike	6/6	6/6	6/6	5/6
Nancy	5/5	5/5	4/5	5/5
Lynn	5/5	5/5	5/5	4/5
Remy	6/6	6/6	6/6	6/6

For easy problems, during the explicit timing condition, Mike, Nancy, Lynn and Remy exceeded 90% accuracy on all sessions while Bill exceeded 90% accuracy on five of six sessions. Compared to easy problems, there was more variability in participants' accuracy on hard problems. Bill scored higher than 90% accuracy on three of six sessions under the untimed condition, while he only had one session with accuracy greater than 90% during the explicit timing condition. Mike scored over 90% accuracy for all six sessions under the untimed condition, and scored greater than 90% accuracy on five of six sessions during explicit timing. Lynn's pattern was similar to Mike's pattern, she exceeded 90% accuracy for all five sessions under the untimed condition, while she scored higher than 90% accuracy on four of five sessions under the explicit timing condition. Remy maintained over 90% accuracy throughout the untimed and explicit timing conditions. Finally, Nancy scored greater than 90% accuracy on four of five sessions under untimed condition, while she exceeded 90% accuracy for all five sessions under the explicit timing condition.

On-task Behavior

Figures 6 to 10 show the results of on-task behavior for all participants under both conditions. Bill performed on-task for a mean of 81% of the observation intervals with a range of 70% to 100% (SD = 8%) under the untimed condition, while his on-task behavior increased to a mean of 92% with a range of 75% to 100% (SD = 6%) under the explicit timing condition. Mike's mean on-task behavior was 98% with a range of 90% to 100% (SD = 3%) under the untimed condition, and he were 100% on task across all the sessions under the explicit timing condition. In contrast to Bill and Mike, Nancy was on-
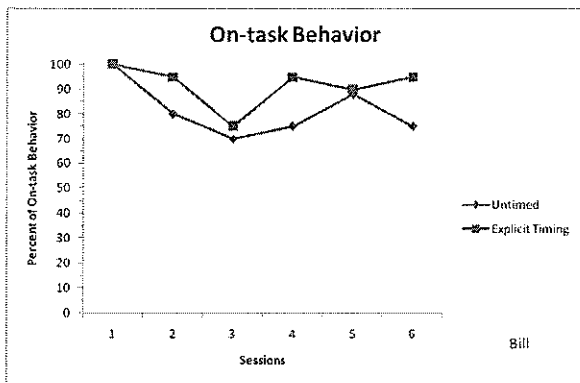
Figure 6. Percent of on-task behavior for Bill.
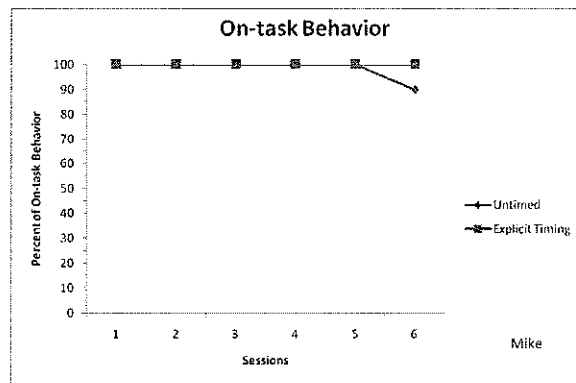
Figure 7. Percent of on-task behavior for Mike.
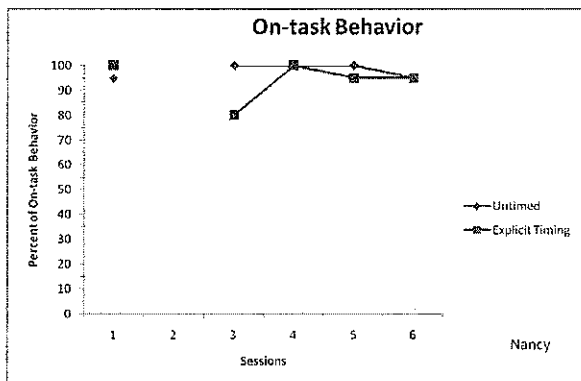
Figure 8. Percent of on-task behavior for Nancy.
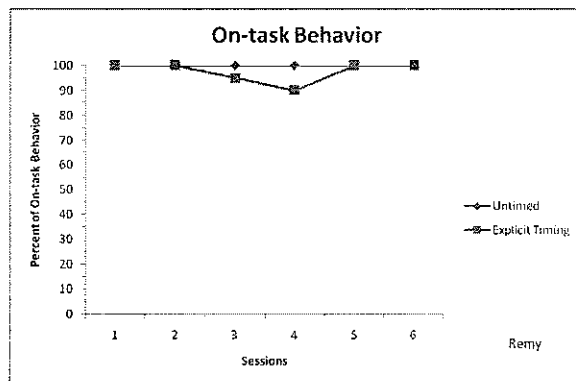
Figure 9. Percent of on-task behavior for Remy.
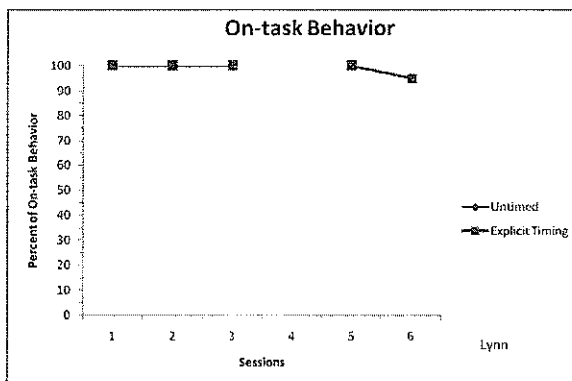
Figure 10. Percent of on-task behavior for Lynn.

task at a mean of 98% with a range of 95% to 100% (SD = 2%) under the untimed

condition, while her on-task behavior decreased to a mean of 94% with a range of 80% to

100% (SD = 6%) under the explicit timing condition. Similar to Nancy, Remy was on-

task a slightly greater percent of observed intervals during the untimed practice than the

explicit timing condition. He was on-task 100% throughout the experiment under the

untimed condition, while he was on-task at a mean of 98% with a range of 90% to 100%

(SD = 3%) under the explicit timing condition. Lynn performed exactly the same way

under both untimed and explicit timing conditions at a mean of 99% on-task with a range

of 95% to 100% (SD = 2%).

DISCUSSION

The primary purpose of the present study was to examine the effectiveness and efficiency of explicit timing with an interspersed assignment for students with mild/moderate disabilities. The secondary purpose was to explore whether explicit timing would produce higher on-task behavior than an untimed condition.

When examining rate of overall digits correct, each participant averaged a higher rate of digits correct per minute under the explicit timing condition than the untimed condition. Furthermore, each participant obtained their highest rate of digits correct under the explicit timing condition. This portion of the results is consistent with the findings of previous research that explicit timing produced higher rates of correct responses compared to the untimed condition (Miller et al., 1995; Rhymer et al., 1998; Rhymer et al., 1999; Van Houten & Thompson, 1976).

An interesting pattern that emerged in the present study was that for four of five participants there was a larger separation between explicit timing and untimed practice during the first few sessions than in the later sessions. In fact, during the last few sessions, Lynn performed higher under the untimed condition than the explicit timing condition. It is possible that the separation was due to the novelty effect of implementing a new intervention, and the initial effect of explicit timing faded over time. Following the first few sessions, each participant's performance under explicit timing stabilized except for Lynn, whose performance under explicit timing continued to decrease. This result was contrary to our initial hypothesis that the participants performance would increase over time.

While one explanation for the observed performance patterns could be the novelty of the explicit timing condition, another explanation could be that participants did not have sufficient motivation to continue responding at a high rate during the explicit timing condition. The experimenter did not provide any specific verbal praise for either completing more problems or reaching higher accuracy, except general feedback like, "thank you for working hard." After completing either condition, explicit timing or untimed practice, each of the participants only received one penny for working on the packet for four minutes. Thus, there was no explicit contingency for maintaining or increasing their performance during the explicit timing condition.

Regarding accuracy, the math facts used in the present study were divided into two categories, easy problems and hard problems. For easy problems, participants maintained high accuracy during both conditions. This outcome is similar to outcomes in previous research on explicit timing where high accuracy levels were maintained even though response rates increased (Miller et al., 1995; Rhymer et al., 1998, 1999; Van Houten & Thompson, 1976).

However, the accuracy for hard problems was slightly more variable across participants than the accuracy for easy problems. Two studies in the literature showed that the explicit timing procedure had decreased accuracy level, either when explicit timing was implemented with students with a low initial accuracy level (Rhymer et al., 1998), or when explicit timing was utilized to practice problems involving multiple steps (Rhymer et al., 2002). The current study differs from the previous studies because the participants in this study completed the hard problems with initially high accuracy, but at

a lower rate than the easy problems. While there was a little more variability across participants with hard problems than with easy problems, it is not clear that explicit timing contributed to the increased errors as was found in previous research (Rhymer et al., 1998, 2002). It is possible that interspersing hard and easy problems on the worksheets mediated any increase in errors on hard problems. Reviewing previous studies, evidence was found that interspersing simple or easy problems among difficult problems increased students' overall completion rates without reducing response rates and accuracy level of difficult problems (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Robinson & Skinner, 2002; Wildmon et al., 2004).

In this study, three of five participants exceeded accuracy criteria in more sessions under the explicit timing condition than the untimed condition. One participant met criteria in all sessions during both the timed and untimed conditions. Only one participant performed more sessions exceeding the accuracy criteria during the untimed condition than the explicit timing condition.

Examination of on-task behavior across all participants, it provided no appreciable difference between explicit timing and untimed conditions for four participants. Bill was the only participant whose on-task behavior showed any variability under different conditions. He performed at a higher on-task behavior under the explicit timing than the untimed condition.

The present study does provide some evidence that explicit timing is effective compared to untimed practice when applied to students with mild/moderate disabilities working on math problems with initially high accuracy levels, nevertheless, several

limitations should be considered. First, explicit timing and untimed practice were administered immediately one after another within 20 minutes, which might result in a carry-over effect across conditions. That is, participants might perform as if they were timed even under untimed condition, or otherwise. Therefore, for the future study, a distinguished break between these two conditions is suggested, which might minimize potential carry-over effects.

Secondly, the self-correction procedure utilized in the present study was different from the self-correction procedure used in Miller et al. (1995), which used teacher-directed self-correction, during which the teacher read each problem and the students read the problem and answered in unison. Students marked the incorrect answers and wrote the correct answers. In the present study, participants were given answer keys and told to complete self-correction and partner practice independently. The evaluation of self-correction results showed some participants made consistent correction errors, which likely contributed to low accuracy levels. Students might need extra help with self-correction other than an answer key, so a teacher-directed self-correction is suggested for teachers who intend to program self-correction into instruction of building math facts fluency in classroom.

In addition, only six sessions were implemented during the experiment. This may be too short to assess the effectiveness of an intervention designed to increase math facts fluency, which requires long-term practice especially for students with disabilities.

Finally, in the current study while explicit timing did produce increases over untimed practice, the effects were not maintained. This may be due to lack of motivation.

This suggests that using preferred reinforcers along with academic targets may in fact result in more sustained effects. In order to examine the effect of explicit timing combined with preferred reinforcers and academic targets, Study 2 was conducted.

STUDY 2

Introduction

Many researchers suggest that academic targets, goals (Ames, 1992; Elliott &

Dweck, 1988; Pipkin, Winters, & Diller, 2007; Was, 2006) and preferred reinforcers

(Carr, Nicolson, & Higbee, 2000; Cote, Thompson, Hanley, & McKerchar, 2007;

DeLeon & Iwata, 1996; Graff, Gibson, & Galiatsatos, 2006; Pace, Ivancic, Edwards,

Iwata, & Page; Paramore & Higbee, 2005; Resetar & Noell, 2008) play an important role

in motivating students' performance. An increasing number of teachers incorporate

either academic targets, or reinforcers, or both into their instruction strategies, or

classroom management systems (Ames, 1992; Elliott & Dweck, 1988; Paramore &

Higbee, 2005; Pipkin et al., 2007).

Academic targets have been used to improve student's performance in different

ways. Pipkin et al. (2007) used a multiple-baseline design across participants to examine

the effect of instruction, academic targets, and reinforcement in isolation as well as in

combination on letter naming with two students, who were at-risk for retention in

kindergarten. Only letters that the participants could not identify correctly were included

in the experiment. Following the baseline, two interventions were implemented. During

intervention 1, instruction, academic targets, and reinforcement were implemented

individually. During intervention 2, three conditions were implemented; instruction plus

reinforcement; academic targets plus reinforcement; and reinforcement only. The results

showed that when academic targets and reinforcement were implemented alone, no

difference was observed on participants' performance compared to the baseline.

Although participants' performance increased somewhat under the instruction condition,

the effect was not maintained for either participant. However, when reinforcement was

combined with instruction and academic targets, both participants demonstrated

improved accuracy level and the performance was sustained and even produced an

upward trend.

Traditionally, teachers select reinforcers arbitrarily or randomly without students'

involvement. Recently researchers have developed several reinforcer assessment

methods to identify the most potent reinforcers for individuals. They are known as

single-stimulus preference assessment (Pace et al., 1985), paired-stimulus preference

assessment (Fisher et al., 1992), multiple-stimulus-with-replacement (MSW) preference

assessment (DeLeon & Iwata, 1996), and multiple-stimulus-without-replacement

(MSWO) preference assessment (DeLeon & Iwata, 1996; Carr et al., 2000; Paramore &

Higbee, 2005).

Of those methods, a three-trial brief MSWO preference assessment (Carr et al.,

2000; Paramore & Higbee 2005) is the least time-consuming and produces results that are

similar to other methods that require more time to implement (e.g., paired-stimulus

assessment, five-trial MSWO assessment). Paramore and Higbee (2005) conducted a

preference assessment for elementary students with emotional behavior disorders in an

educational setting by administering a three-trial brief MSWO preference assessment.

The researchers also conducted an A-B design experiment to evaluate the relative

reinforcement effects for three types of stimuli, high, medium, and low preference.

During the brief MSWO preference assessment, five edible stimuli were presented in an array, and the participants were instructed to choose one. The selected stimulus was not replaced until the last stimulus was selected at the end of each trial. The observer recorded the order in which stimuli were selected and then categorized the stimuli as high preference, medium preference, and low preference according to the ranking. Later on, based on the results of the preference assessment, a reinforcer evaluation procedure took place in the general education classroom. The students' on-task behavior was observed for three consecutive 10-minute observation intervals. Participants earned high-, medium-, or low- preference reinforcers in each session, during which only one type of reinforcer (high-, medium-, or low-preference reinforcers) was available for that session. The results showed that the high-preference reinforcers generated the highest on-task behavior, and the medium-preference reinforcer produced the next highest on-task behavior across all three participants.

It is possible that using preferred reinforcers along with academic targets may produce more sustained effects with the explicit timing intervention examined in Study 1. The purpose of this study was to extend the research in Study 1 by examining the effects of explicit timing combined with preferred reinforcers and academic targets on rate of overall digits correct per minute on interspersed assignments with students with mild/moderate disabilities.

Research Questions

1. To what extent do students with mild/moderate disabilities have a higher rate of overall digits correct on interspersed assignments during explicit timing combined

with high-preference reinforcers plus academic targets than during explicit timing combined with low-preference reinforcers plus academic targets?

2. To what extent do students with mild/moderate disabilities have a higher accuracy of easy problems/hard problems on interspersed assignments with high-preference reinforcers plus academic targets than low-preference reinforcers plus academic targets during the explicit timing condition?

METHOD

Participants and Settings

The same five students who participated in Study 1 participated in Study 2. The setting in Study 2 remained the same as in Study 1.

Materials

The same type of interspersal assignments that were used in Study 1 were used in Study 2.

Dependent Variables

The dependent variables were rate of overall digits correct per minute, percent of digits correct for easy problems, and percent of digits correct for hard problems. They are recorded and calculated in the same manner as in Study 1.

Independent Variables

During the explicit timing condition, high-preference reinforcers plus progressive academic targets, high-preference reinforcers plus static academic targets, low-preference reinforcers plus static academic targets, and again high-preference reinforcers plus static academic targets were implemented sequentially.

Experimental Design

In study 2, a reversal between high-preference and low-preference reinforcers experimental design was used. Under explicit timing, high-preference reinforcers plus academic targets and low-preference reinforcers plus academic targets were implemented.

Procedures

Preference Assessment

The experimenter conducted a three-trial brief MSWO preference assessment with each participant to identify their current individual high- or low-preference reinforcers before implementation of each condition. The experimenter selected six items, including both edible and tangible items, from the "Classroom Store." During the assessment procedure, the experimenter placed an array of six items on the table in front of a participant and instructed the participant to select an item by saying, "Take the one you want to earn for math timing." After a stimulus was selected, the item was not replaced. The experimenter then took the remaining items and arranged the items evenly in an array. The experimenter then prompted the participant to select the next item using the same direction used earlier. The procedure continued until all the items were selected. The experimenter recorded the order in which the participant selected the items. The item that the participant selected first was assigned a rank of 1, the item chosen second was assigned a rank of 2, and so on. After all the items were chosen for the first trial, then the procedure was repeated in the same manner for two additional trials. The experimenter never repeated instructions, the participants always selected an item, and

the participants never selected two or more items at once. After having administered all three trials, the experimenter added up the ranks for each stimulus. The sum of ranks were then ordered from least to greatest, and the item with the lowest sum was assigned the highest overall rank, which was considered as the high-preference reinforcer, and the item with the highest sum was assigned the lowest rank, which was identified as the low-preference reinforcer. (See Appendix D for brief MSWO data sheet.)

Baseline

For each participant, the last explicit timing phase in Study 1 served as the baseline for Study 2.

High-preference-reinforcer Intervention 1

During high-preference-reinforcer intervention 1, explicit timing combined with high-preference reinforcers plus progressive academic targets was implemented. The high-preference reinforcer was identified based on the preference reinforcer assessments conducted prior to the intervention. The experimenter set the initial academic targets based on baseline performance and a level that maximized the probability that the participants would achieve the initial goals. If participants met their targets, new academic targets were established by rounding up the scores that the participants obtained in the current session. If participants did not meet their academic targets, the targets were held at the same level for the next session.

At the beginning of intervention, the experimenter handed the interspersed assignment packets to each participant and said, "Your goal is ____. If you meet your goal, you will earn ____ (the high preference reinforcers for individual participant)."

Similar to Study 1 after administering the explicit timing condition, the experimenter collected the packets and delivered one penny to each participant, saying, "thank you for working hard." And then the experimenter corrected the assignment packets and calculated each participant's rate of digits correct per minute. After the experimenter wrote the results on the first page of the packet circled with a red pen, the experimenter delivered the packets to each participant randomly. If the participant met his/her goal, the experimenter handed the high-preference reinforcer to the participant and said, "You've got __digits correct for 1 minute, you passed your goal ___. Keep up the good work. Here's your reward (high-preference reinforcer)." If the participant did not meet his/her goal, the experimenter would say, "Your goal is ___ digits correct for 1 minute, you've got ___. It's close. Work harder next time." No reinforcer was delivered. At last, the experimenter collected all the packets and the participants started their daily math class.

High-preference-reinforcer Intervention 2

The procedure was the same as described in high-preference-reinforcer intervention 1, except the criteria for setting academic targets was changed. During this phase, the academic target for each participant was the last time they met their criteria. For Bill, Nancy and Mike, the targets were held stable for the rest of the experiment.

High-preference-reinforcer Intervention 3

During high-preference-reinforcer intervention 2, Lynn and Remy did not reach their academic targets, so an extra high-preference reinforcer intervention condition was added for these two participants. Their academic targets were adjusted to the rate of digits correct per minute they obtained during the last session in the high-preference-

reinforcer intervention 2 condition. The remaining procedures were the same as during high-preference-reinforcer intervention 2.

Low-preference-reinforcer Intervention

The low-preference-reinforcer intervention took place in the same manner as the high-preference-reinforcer interventions, except low-preference reinforcers were implemented instead of high-preference reinforcers.

High-preference-reinforcer Reversed Intervention

The experimenter administered the current intervention in the same manner as in the previous condition, except that the high-preference reinforcers were reinstated instead of low-preference reinforcers.

<div align="center">

Interscorer Agreement

</div>

The experimenter scored all the packets initially. To obtain interscorer agreement data, approximately 33% of the packets were randomly selected to be rescored by a second scorer independently. Percentage of interscorer agreement for each packet was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Across packets, interscorer agreement scores ranged from 97% to 100% with an average of 99.9% for both the rate of overall digits correct and accuracy of easy and hard problems.

Treatment Integrity

Treatment integrity was assessed by an independent observer during 21% of the sessions. The observer used a checklist created by the experimenter to collect data on whether the experimenter appropriately implemented all the steps on the checklist. The treatment integrity was calculated by dividing the number of steps checked by the total steps listed and multiplying by 100%. Across the sessions, the treatment integrity was 100%.

RESULTS

Reinforcer Preference Assessment

The results of each participant's high- and low- preference reinforcers for each

condition are presented in Table 4. As seen in Table 4, Mike displayed consistency with

high- and low-preference reinforcers throughout the experiment. Nancy, Lynn and Remy

exhibited relatively stable preferences over time. Lynn and Remy selected two different

items for high-preference reinforcers, and two items for low-preference reinforcers.

Nancy also selected two different items for high-preference reinforcers, but one item for

low-preference reinforcers. While Bill's data were more variable, he selected three

different high-preference reinforcers and two low-preference reinforcers across the four

conditions.

Rate of Overall Digits Correct During Explicit Timing

Figures 11 to 15 visually present the rate of overall digits correct per minute

during baseline and the experimental conditions under explicit timing for each participant.

Bill produced a marked increase when high-preference reinforcers plus progressive

academic targets were implemented during explicit timing in session 7. Bill achieved

15.5 overall digits correct per minute, which exceeded his academic target of 12 overall

digits correct per minute. According to the criteria for determining progressive academic

targets, Bill's next academic target was 16 overall digits correct per minute. However,

Bill missed his academic target for the next two sessions; he obtained 13.3 and 12.3

overall digits correct per minute in session 8 and session 9 respectively, thereby producing a decreasing data path. Similar to Bill, Remy exceeded his explicit academic target in session 7, and produced an appreciable increase when high-preference reinforcers plus an academic target was first introduced. On session 7, his academic target was 18 digits correct per minute, while he reached 23.5 digits correct per minute. However, when he did not meet his next academic target on session 8, he decreased his rate of overall digits correct per minute gradually for the following three sessions.

Nancy and Lynn both reached their academic targets for the first two sessions when high-preference reinforcers plus progressive academic targets were implemented, and produced noticeable increases on the rate of overall digits correct per minute. However, they both missed their academic targets on session 9 and session 10, thus exhibiting a decreasing data path under this condition.

Mike was the only participant who did not make an immediate increase when high-preference reinforcers plus progressive academic targets was first introduced. For session 7 and session 8 he exceeded his academic target by 3 digits correct per minute (from 12 to 15) and 1 digit correct per minute (from 18 to 19) respectively. When his academic target increased to 20 overall digits correct per minute, he did not reach it for the last two sessions. However, he still made identifiable progress with the rate of 19.8 overall digits correct per minute on session 9, although he decreased the rate to 18.5 overall digits correct per minute on the last session. In contrast to the other participants, Mike produced an increasing trend during this condition.

Table 4

Results of Reinforcer Preference Assessment

Bill	HP_1	HP_2	LP	HP_R	
High Preference	M&M	Eraser	Wrist band	M&M	
Low Preference	Ponytail Band	Ponytail Band	Ponytail Band	Wrist band	
Mike	HP_1	HP_2	LP	HP_R	
High Preference	Laffy Taffy	Laffy Taffy	Laffy Taffy	Laffy Taffy	
Low Preference	Ponytail Band	Ponytail Band	Ponytail Band	Ponytail Band	
Nancy	HP_1	HP_2	LP	HP_R	
High Preference	Tootsie Roll	Laffy Taffy	Laffy Taffy	Laffy Taffy	
Low Preference	Ponytail Band	Ponytail Band	Ponytail Band	Ponytail Band	
Lynn	HP_1	HP_2	HP_3	LP	HP_R
High Preference	Eraser	Laffy Taffy	Laffy Taffy	Laffy Taffy	Laffy Taffy
Low Preference	Ponytail Band/ M&M	M&M	Ponytail Band/ M&M	Ponytail Band	M&M
Remy	HP_1	HP_2	HP_3	LP	HP_R
High Preference	Tootsie Roll	Laffy Taffy	Laffy Taffy	Laffy Taffy	Laffy Taffy
Low Preference	Ponytail Band/ M&M	Ponytail Band	M&M	M&M	M&M

Overall Digits Correct
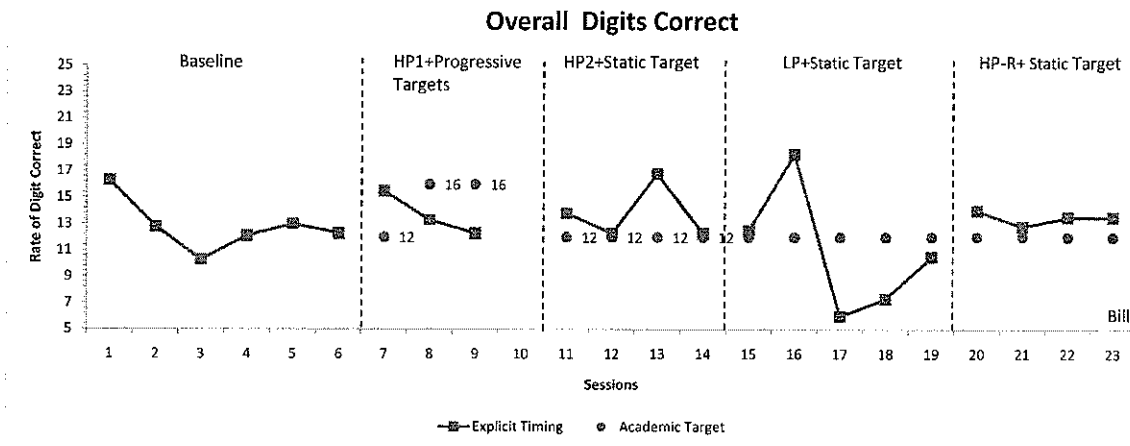
Figure 11. Rate of overall digits correct for Bill.

Overall Digits Correct
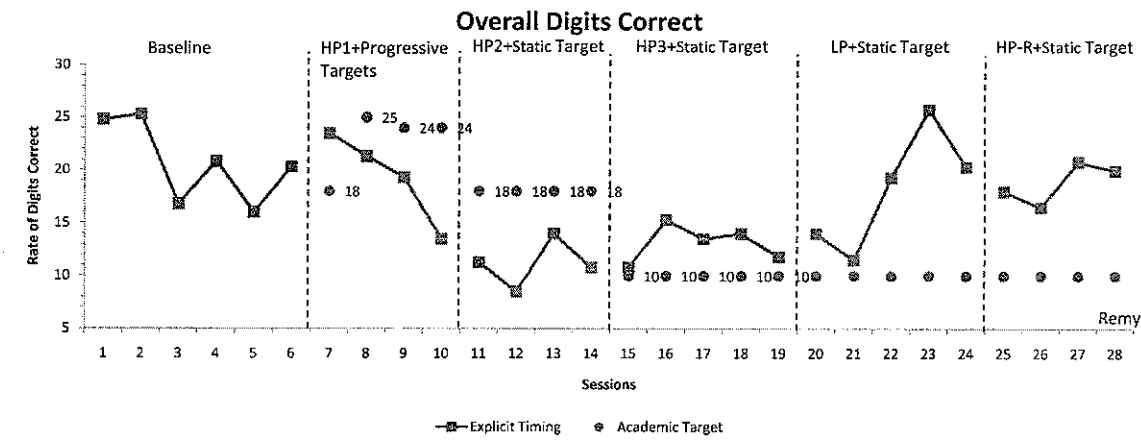
Figure 12. Rate of overall digits correct for Remy.

Overall Digits Correct
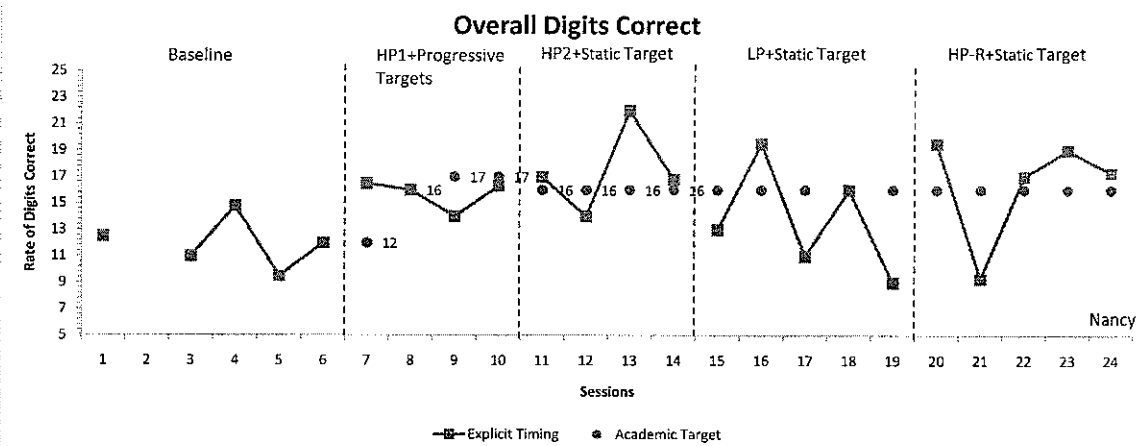
Figure 13. Rate of overall digits correct for Nancy.
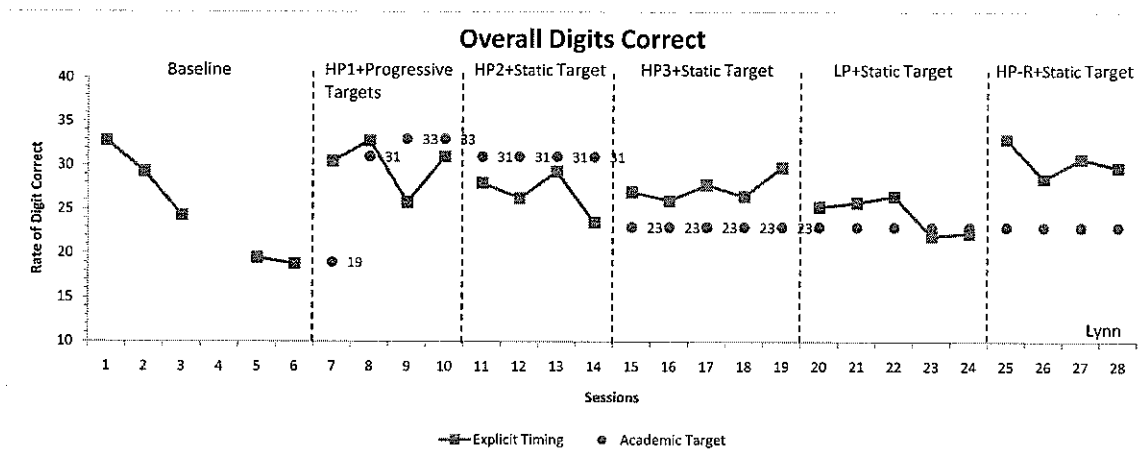
Figure 14. Rate of overall digits correct for Lynn.
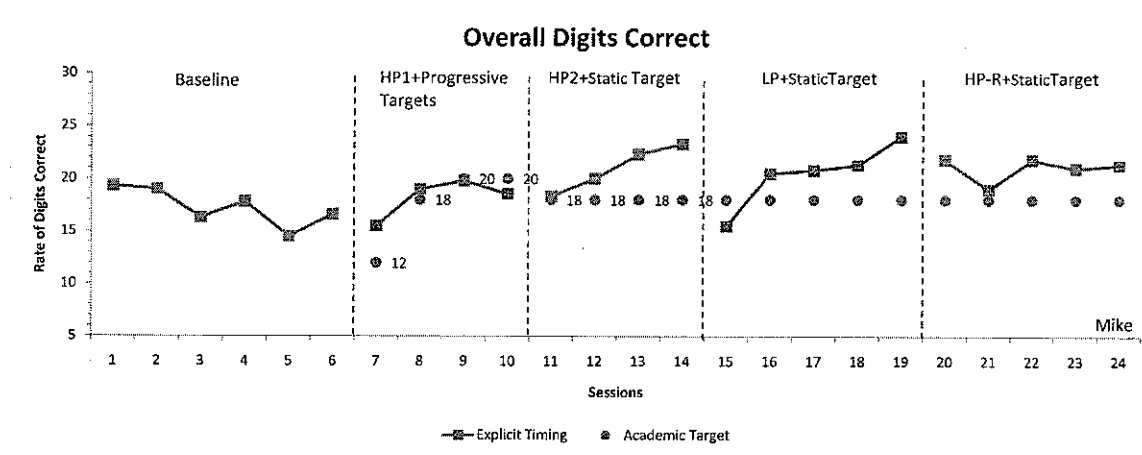
Figure 15. Rate of overall digits correct for Mike.

The majority of participants did not reach their academic targets when we used progressive academic targets. Because of insufficient opportunities for contacting with the reinforcers, we adopted a static academic target during the high-preference-reinforcer intervention 2 condition.

During this condition, the experimenter adjusted participants' academic targets to the score received the last time the participants met criteria. Additionally, the academic

target was held at the same level for the rest of experimental sessions if participants met their goals and lowered further if participants did not meet their goal.

During the high-preference-reinforcer intervention 2 condition, Bill exceeded his academic target of 12 overall digits correct per minute on four of four sessions and maintained a relatively stable data path. Nancy exceeded her explicit academic targets on three of four sessions and produced an increasing data path. Similar to Bill and Nancy, Mike produced an increasing trend exceeding his explicit academic targets on four of four sessions. However, Lynn and Remy did not meet their targets for all sessions. Lynn showed declining performance with the mean rate of 26.8 overall digits correct per minute, while her academic target was 31 overall digits correct per minute. Remy produced a slightly increasing trend but maintained at the mean rate of 11.2 overall digits correct per minute, which was far below his academic target, 18 overall digits correct per minute.

Since Lynn and Remy failed to meet their academic targets, an additional condition was implemented with high-preference reinforcers plus a reduced academic target. The academic target was reduced to the rate of digits correct per minute obtained in the last session of the previous condition. During this condition, both participants exceeded their academic targets for all sessions, and improved their performance. Lynn produced an upward data path, while Remy sustained a stable trend.

When participants either produced upward trends, or maintained stable data paths, a low-preference reinforcer plus static academic target condition was implemented. Bill exceeded his academic target on two of five sessions with a decreasing data path. Nancy

and Lynn produced a similar downward data path. Nancy exceeded her academic target on two of five sessions, and Lynn exceeded her target on three of five sessions. In contrast, Mike and Remy produced increasing data paths when low-preference reinforcers plus static academic targets were implemented. Mike exceeded his target on four of five sessions, and Remy met his target on all five sessions.

When high-preference reinforcers plus academic target were reinstated changes in performance trends were observed for each participant. Bill averaged 10.9 overall digits correct per minute during the low-preference reinforcer condition and had a decreasing performance trend. During the high preference reinforce condition his mean rate increased to 13.5 overall digits correct per minute and had a stable performance trend. Nancy's data pattern is similar to Bill's performance pattern. She averaged 13.7 digits correct per minute during the low-preference reinforcer condition, while she achieved an average rate of 16.4 digits correct per minute during the high-preference reinforcer condition. Her data trend decreased during the low-preference-reinforcer condition while her data trend stabilized above her academic target during the high-preference-reinforcer condition. Lynn obtained a mean rate of 24.4 digits correct per minute with low-preference reinforcers, while her performance increased to 30.5 digits correct per minute when the high-preference reinforcer condition was reinstated. However, Mike and Remy performed differently from other participants in two aspects. First, unlike other participants who made appreciable increases when low-preference reinforcers switched back to high-preference reinforcers, Mike and Remy only obtained slight increases. Mike averaged 20.4 digits correct per minute with low-preference reinforcers, and 21.0 digits

correct per minute with high-preference reinforcers. Remy averaged 18.2 digits correct per minute with low-preference reinforcers, while he gained a mean rate of 18.8 digits correct per minute with high-preference reinforcers. Second, they both created increasing data paths under low-preference-reinforcer condition, while other participants produced decreasing trends.

Four of five participants exceeded their academic target on all sessions. Nancy met her academic target on four of five sessions. Furthermore, four of five participants either maintained stable performance, or produced increasing data paths when the high-preference reinforcer condition was reinstated. Lynn was the only participant who generated a decreasing data path when high-preference reinforcers were re-implemented. Lynn's performance increased in the first one or two sessions for five of six phases. Her rate of overall digits correct decreased for the remaining sessions during each condition.

Accuracy for Easy and Hard Problems During High-Preference and Low-Preference Reinforcer Conditions

Table 5 shows the number of sessions during each condition when participant performance exceeded 90% for easy and hard problems. For easy problems, all participants exceeded 90% accuracy with both high- and low-preference reinforcers during each session.

For hard problems, Nancy, Mike and Remy exceeded 90% accuracy with both high- and low-preference reinforcers for all sessions. Lynn exceeded 90% accuracy for all sessions when high-preference reinforcers were initially introduced, and low-preference reinforcers were implemented. However, when high-preference reinforcers

were reinstated, she exceeded 90% accuracy for only one of four sessions. Bill did not reach 90% accuracy when high-preference reinforcers were implemented for all sessions, while he exceeded 90% accuracy three of four sessions when low-preference reinforcers were introduced. Finally, when high-preference reinforcers were reinstated, his accuracy decreased again and he did not reach 90% accuracy for all sessions.

DISCUSSION

The primary purpose of Study 2 was to examine the effect of explicit timing combined with preferred reinforcers plus academic targets on the rate of overall digits correct per minute using interspersal assignments for students with mild/moderate disabilities. The current study also investigated the effectiveness of academic targets, and the different impacts produced by high- and low-preference reinforcers on the rate of digits correct per minute on interspersed assignments for students with mild/moderate disabilities.

The present study contributes to the literature in several ways. First, it was clear, that high preference reinforcers did not sufficiently motivate students to meet

Table 5

Accuracy of Easy and Hard Problems with High-preference and Low-preference Reinforcers plus Academic Targets During Explicit Timing Condition

	HP + Academic Target		LP + Academic Target		HP_R + Academic Target	
	Easy>90%	Hard>90%	Easy>90%	Hard>90%	Easy>90%	Hard>90%
Nancy	4/4	4/4	5/5	5/5	5/5	5/5
Mike	4/4	4/4	5/5	4/5	5/5	5/5
Remy	5/5	5/5	5/5	4/5	4/4	4/4
Lynn	5/5	4/5	5/5	5/5	4/4	1/4
Bill	4/4	0/4	5/5	3/5	4/4	0/4

increasingly challenging academic targets. On the contrary, there is some evidence to suggest that this strategy might have impeded students' progress toward their academic target. Initially, four of five participants exceeded their academic targets with high-preference reinforcers. However, participants gradually decreased their correct response rates when new academic targets were established progressively. It is possible that the progressive academic targets increased so dramatically that the participants could not keep up with the new standards, which discouraged them working towards the goals. In addition, this resulted in less contact with reinforcers, and inadequate reinforcement most likely failed to inspire participants to be fully motivated.

With the lesson we have learned from the previous conditions, we decreased academic targets for each participant to a comfortably achievable level, and changed progressive academic targets to static academic targets for the rest of experiment. The implementation of static academic targets plus high-preference reinforcers produced appreciable increases and upward data paths for Nancy, Mike, and Lynn. Although Bill did not exhibit an increasing trend, he did make an improvement and created a stabilized data path with a relatively high rate of overall digits correct per minute compared to his baseline.

Second, the current study showed that high-preference reinforcers increased response rate and maintained high performance levels for students with mild/moderate disabilities, while low-preference reinforcers failed to sustain the effects. The results showed that four of five participants, Bill, Nancy, Mike, and Lynn, gained a higher mean rate of overall digits correct per minute when high-preference reinforcers were

implemented. In contrast, their mean rate of digits correct per minute decreased when high-preference reinforcers were replaced with low-preference reinforcers. When high-preference reinforcers were reinstated, the participants reverted to the higher correct response rates again. These findings indicated that explicit timing combined with high-preference reinforcers plus static academic targets led to higher correct response rates than with low-preference reinforcers on interspersed assignments for students with mild/moderate disabilities.

The performance differences observed between the high preference and low preference condition for three of five participants is consistent with previous studies (e.g., Carr et al., 2000; Graff et al., 2006; Paramore & Higbee, 2005). However, two of five participants, Mike and Remy, exhibited increasing trends when low-preference reinforcers were implemented. It is possible that the low-preference reinforcers were not really low-preference for Remy.

However, Mike's comments on low-preference reinforcers might give us some idea about his performance. It was approaching Christmas when we implemented low-preference reinforcers. On the second day of implementation of the low-preference reinforce condition, Mike said, "I can give ponytail bands (his low-preference reinforcers) to my baby sister, she likes it." And also Mike asked for different colors when he earned ponytail bands. When examining Mike's data path, we can clearly see that he did not reach his academic target for the first day when low-preference reinforcers were initially introduced, but he increased his rate of digits correct per minute dramatically for the second session and continued making progress for the rest of the sessions. According to

Mike's comments and performance, it was possible that Mike convinced himself that it was worthwhile working hard for the ponytail bands so he could use them as Christmas gifts for his baby sister. Most previous studies on reinforcers assessment focused on persons with severe or profound disabilities. Mike's comments suggest that students with mild/moderate disabilities might have the ability to convert low-preference reinforcers into high-preference reinforcers in certain contexts, which students with severe disabilities might not be able to accomplish. Additional research is needed to examine this possibility and determine under what conditions reinforcer preferences change.

When examining easy problems, all participants exceeded 90% accuracy with both high- and low-preference reinforcers for all sessions during explicit timing. This result is consistent with previous studies (Miller et al., 1995; Rhymer et al., 1998; Van Houten & Thompson, 1976) and with Study 1 where explicit timing increased correct response rates without decreasing accuracy when it is utilized to practice problems with high initial accuracy level. With hard problems, three of five participants met the accuracy criteria with both low- and high-preference reinforcers for all sessions. However, noticeable decreases were observed in accuracy for hard problems when high-preference reinforcers were implemented for two of five participants. Bill did not reach 90% accuracy during both high-preference-reinforcer phases for all sessions, while he exceeded the criteria three of five sessions when low-preference reinforcers were implemented. Lynn only met 90% accuracy for one of four sessions when high-preference reinforcers were reinstated. A possible explanation for Lynn and Bill failing to meet the criteria with implementation of high-preference reinforcers might be that they

sacrificed accuracy for hard problems to achieve overall high correct response rates in order to earn high-preference reinforcers.

Finally, the current study employed a three-trial brief MSWO method to identify high- and low-preference reinforcers for each participant prior to each experimental condition. The results showed four of five participants were relatively consistent with their high- and low-preferred reinforcers. However, Bill exhibited much variability, which suggested student's preference might change over time. Brief MSWO could be used as an efficient and effective method to identify student's current preference, thereby enhancing the effect of an ongoing reinforcement program.

In Study 1, all five participants produced declining data paths under the explicit timing condition, which indicated that explicit timing alone is not sufficient to maintain the effect. While in Study 2 with explicit timing combined with academic targets and reinstatement of high-preference reinforcers, two of five participants produced increasing data paths, two participants maintained a higher performance rate compared to their baseline data, and only one participant, Lynn, produced a decreasing data path. However, when examining her performance throughout the experiment, we found that Lynn produced downward trends on five of six conditions. She created an idiosyncratic pattern across conditions, which is a large increase in the first few sessions and then an apparent decrease was observed in the remaining sessions in each condition. Although only four to five data points were presented when reinstated to the high-preference reinforcement condition, other than Lynn, the remaining participants' data paths appeared to stabilize rather than decrease as observed in Study 1. Thus, explicit timing combined with

preferred reinforcers and academic targets produced a more sustainable effect than explicit timing alone.

The present study has several limitations that need to be addressed. First, achievable targets likely ensured that students would contact reinforcers and maintain continuous motivation to achieve targets in the short term. However, practice improves students' performance, and, over time, static targets might not challenge students to increase their performance rate. For instance, Bill and Nancy appeared to not pay full attention to their assignments during the last phase of the experiment. When they completed a certain amount of problems, they either stopped writing and stared at the worksheets, or wrote answers slowly, or repeated writing the same answers again and again at the same spot. A hypothesis might be they thought they had finished enough problems to get their rewards, so there was no reason to keep working. This implies that when educators consider using academic targets as a component of an instructional strategy, progressive academic targets might be a better choice for students to gain continuous motivation towards achieving goals in the long run. However, educators need to determine academic targets with caution, and only increase targets after students demonstrate consistent fluency at a target level.

Second, four 1-minute timing intervals were implemented in the current study. During the experiment, boredom and tiredness were observed for some participants, who might have short attention spans. So for future studies, less timing intervals, such as two-minute, or three-minute intervals, might be a better choice for students who are not able to engage in long-term intensive practices.

Third, explicit timing, setting academic targets, using preferred reinforcers, and interspersal assignments have all been shown to be effective methods for improving students' performance. In the current study, we combined all four components in one package to investigate students' academic performance. Unfortunately, there is no way to determine the portion of effects contributed by each component.

Finally, interspersed assignments have been proven to be an effective intervention for practicing hard problems and improved students' performance in previous studies (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins et al., 2005; Robinson & Skinner, 2002; Wildmon et al., 2004). However, in the present study, a control condition was not in place to provide comparison to validate the effectiveness of interspersal assignments. Therefore, there is not a certain way to identify how much interspersed assignment facilitates participants' performance. In future studies, discrete assignments would serve as a comparison to identify the effectiveness of interspersal assignments.

REFERENCES

Ames, C. (1992). Classroom: Goals, structures, and student motivation. *Journal of Educational Psychology, 84*(3), 261-271.

Benner, G. J., Allor, J. H., & Mooney, P. (2008). An investigation of the academic processing speed of students with emotional and behavioral disorders served in public school settings. *Education and Treatment of Children, 31*, 307-332.

Benner, G. J., Nelson, J. R., Allor, J. H., Mooney, P., & Dai, T. (2008). Academic processing speed mediates the influence of both externalizing behavior and language skills on the academic skills of students with emotional disturbance. *Journal of Behavior Education, 17*, 63–78.

Boisseau, B. (2008). FYI: The AIP bulletin of science policy news- US, international TIMSS scores released. *American Institute of Physics. Number 121- December 22, 2008.* Retrieved from http://www.aip.org/fyi/2008/121.html

Bryant, B. R., & Bryant, D. P. (2008). Introduction to the special series: mathematics and learning disabilities. *Learning Disability Quarterly, 31*, 3-8.

Bryant, D. P. (2005). Commentary on early identification and intervention for students with mathematics difficulties. *Journal of Learning Disabilities, 38*, 340-345.

Carr, J. E., Nicolson, A. C., & Higbee, T. S. (2000). Evaluation of a bref multiple-stimulus preference assessment in a naturalistic context. *Journal of Applied Behavior Analysis, 33*(3), 353-357.

Cates, G. L., & Erkfritz, K. N. (2007). Effects of interspersing rates on students performance on and preferences for mathematics assignments: Testing the discrete task completion hypothesis. *Psychology in the Schools, 44,* 615-625.

Cates, G. L., & Rhymer, K. N. (2006). Effects of explicit timing on elementary students' oral reading rates of word phrases. *Reading Improvement, 43,* 148-156.

Cates, G. L., & Skinner, C. H. (2000). Getting remedial mathematics students to prefer homework with 20% and 40% more problems: An investigation of the strength of the interspersing procedure. *Psychology in the Schools, 37,* 339- 347.

Clark, S. L., & Rhymer, K. N. (2003). Student preference for explicit timing and interspersal procedures as a function of math problem completion rates: testing the discrete task completion hypothesis. *Journal of Behavioral Education, 12,* 275-286.

Codding, R. S., Shiyko, M., Russo, M., Birch, S., Fanning, E., & Jaspen, D. (2007). Comparing mathematics interventions: Does initial level of fluency predict intervention effectiveness? *Journal of School Psychology, 45,* 603-617.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis.* Upper Saddle River, NJ: Pearson Education.

Cote, C. A., Thompson, R. H., Hanley, G. P., & McKerchar, P. M. (2007). Teacher refort and direct assessment of preferences for identifing reinforcers for young children. *Journal of Applied Behavior Analysis, 40*(1), 157-166.

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation

format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis,*

29(4), 519-533.

Elliott, E. S., & Dweck, C. S. (1988). Goals: an approach to motivation and achievement.

Journal of Personality and Social Psychology, 54(1), 5-12.

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J.C., & Slevin, I.

(1992). A Comparison of two approaches for identifying reinforaers for persons

with severe and profound disabilities. *Journal of Applied Behavior Analysis, 25*(2),

491-498.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning*

Disabilities, 37, 4-15.

Gersten, R., & Chard, D. (1999). Number sense: Rethinking arithmetic instruction of

students with mathematical disabilities. *Journal of Special Education, 33,* 18-28

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions

for students with mathematics difficulties. *Journal of Learning Disabilities, 38,*

293–304.

Graff, R. B, Gibson, L., & Galiatsatos, G. T. (2006). The Impact of high-and low-

preference stimuli on vocational and academic performances of youths with

severe disabilities. *Journal of Applied Behavior Analysis, 39*(1), 131-135.

Hawkins, J., Skinner, C. H., & Oliver, R. (2005). The effects of task demands and

additive interspersal ratios on fifth-grades' mathematics accuracy. *School*

Psychology Review, 34, 543-555.

Hudson, P. P., & Miller, S. P. (2006). *Designing and implementing mathematics instruction for students with diverse learning needs*. Boston, MA: Pearson Education.

Johnson, K., & Morningside Academy. (2007). *Morningside mathematics fluency*. Seattle, WA: Morning Press.

Jordan, N. C., Hanich, L. B., & Kaplan, D. (2003). A longitudinal study of mathematical competencies in children with specific mathematics difficulties versus children with comorbid mathematics and reading difficulties. *Child Development, 74,* 834-850.

Lee, J., Grigg, W.S., & Dion, G.S. (2007). *The Nation's report card: mathematics 2007*. National Center for Education Statistic. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2007494.

Miller, A. D., Hall, S. W., & Heward, W. L. (1995). Effects of sequential 1-minute time trials with and without inter-trial feedback and self-correction on general and special education students' fluency with math facts. *Journal of Behavioral Education, 5,* 319-345.

National Council of Teacher of Mathematics (NCTM) (2006). Curriculum focal points for mathematics in prekindergarten through eight grades. Retrieved from http://www.nctmmedia.org/cfp/focal_points_by_grade.pdf

Neef, N. A., Iwata, B. A., & Page, T. J. (1980). The effects of interspersal training versus high-density reinforcement on spelling acquisition and retention. *Journal of Applied Behavior Analysis, 13, 153-158.*

Nichols, W. D., Rupley, W. H., & Rasinski, T. (2009). Fluency in learning to read for

    meaning: Going beyond repeated readings. *Literacy Research and Instruction, 48,*

    1-13.

Pace, G. M., Ivancic, M. T., Edwards, G. L., Iwata, B. A., & Page, T. J. (1985).

    Assessment of stimulus preference and reinforcer value with profoundly retarded

    individuals. *Journal of Applied Behavior Analysis, 18*(3), 249-255.

Paramore, N. W., & Higbee, T. S. (2005). An Evaluation of a brief multiple-stimulus

    preference assessment with adolescents with emotional-behavioral disorders in an

    educational setting. *Journal of Applied Behavior Analysis, 38*(3), 399-403.

Patton, J. R., Cronin, M. E., Bassett, D. S., & Koppel, A. E. (1997). A life skills

    approach to mathematics instruction: Preparing students with learning disabilities

    for the real-life math demands of adulthood. *Journal of Learning Disabilities, 30,*

    178-187.

Pellegrino, J. W. & Goldman, S. R. (1987). Information processing and elementary

    mathematics. *Journal of Learning Disabilities, 20,* 23-57.

Pipkin, C. S. P, Winters, S. W., & Diller, J. W. (2007). Effects of instruction, goals, and

    reinforcement on academic behavior: Assessing skill versus reinforcement deficits.

    Journal of Early and Intensive Behavior Intervention, 4(4), 648-657.

Poncy, B. C., Skinner, C. H., & Jaspers, K. E. (2007). Evaluating and comparing

    interventions designed to enhance math fact accuracy and fluency: Cover, copy,

    and compare versus taped problems. *Journal of Behavioral Education, 16,* 27-37.

Rasinski, T. V. (2000). Speed does matter in reading. *The Reading Teacher, 54,* 146-151.

Resetar, J. L., & Noell, G. H. (2008). Evaluation preference assessments for use in the general education population. *Journal of Applied Behavior Analysis*, *41*(3), 447-451.   ,

Rhymer, K. N., & Morgan, S. K. (2005). Comparison of the explicit timing and interspersal interventions: Analysis of problem completion rates, student preference, and teacher acceptability. *Journal of Behavioral Education, 14*, 283-303.

Rhymer, K. N., Henington, C., Skinner, C. H., & Looby, E. J. (1999). The effects of explicit timing on mathematics performance in second-grade Caucasian and African American students. *School Psychology Quarterly, 14*, 397-407.

Rhymer, K. N., Skinner, C. H., Henington, C., D'Reaux, R. A., & Sims, S. (1998). Effects of explicit timing on mathematics problem completion rates in African-American third-grade elementary students. *Journal of Applied Behavior Analysis, 31,* 673-677.

Rhymer, K. N., Skinner, C. H., Jaskson, S., McNeill, S., Smith, T., & Jackson, B. (2002). The 1-minute explicit timing intervention: The influence of mathematics problem difficulty. *Journal of Instructional Psychology, 29,* 305-311.

Riley, R. W. (1997). In math and college-going, middle school makes all the difference. *Middle School Journal,* 3-7.

Robinson, S. L., & Skinner, C. H. (2002). Interspersing additional easier itens to enhance mathematics performance on subtests requiring different task demands. *School Psychology Quarterly, 17*(2), 191-205.

Skinner, C. H. (2002). An empirical analysis of interspersal research evidence, implications, and applications of the discrete task completion hypothesis. *Journal of School Psychology, 40,* 347- 368.

Van Houten, R., & Thompson, C. (1976). Brief research report: The effects of explicit timing on math performance. *Journal of Applied Behavior Analysis, 9,* 227-230.

Van Houten, R., Hill, S., & Parsons, M. (1975). An analysis of a performance feedback system: the effects of timing and feedback, public posting, and praise upon academic performance and peer interaction. *Journal of Applied Behavior Analysis, 8,* 449-457.

Van Houten, R., Morrison, E., Jarvis, R., & McDonald, M. (1974). The effects of explicit timing and feedback on compositional response rate in elementary school children. *Journal of Applied Behavior Analysis, 7,* 547-555.

Was, W. (2006). Academic achievement goal orientation: taking another look. *Electronic Journal of research in Education Psychology, 4(3)*(10), 529-550.

Wildmon, M. E., Skinner, C. H., Watson, T. S., & Garret, L. S. (2004). Enhancing assignment perceptions in students with mathematics learning disabilities by including more work: An extension of interspersal research. *School Psychology Quarterly, 19,* 106-120.

APPENDICES

Appendix A

On-Task Behavior Recording Sheet

On-Task Behavior Recording Sheet

Each square below represents an interval or a time sample observation.
Mark | = behavior was observed, or ◯ = behavior was not observed.

Name _Name_

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Recorder's initials: _____   Percent of observations with + = _____
Notes:

Target Behavior/Objective _____ Date: _____ Condition: _____

Special Education 5010
Department of Special Education and Rehabilitation
Utah State University

Appendix B

Statement for Untimed and Explicit Timing Conditions for Study 1

Statement for Untimed Sessions for Study 1

1. Start when the experimenter says "please start",

2. Work hard and try your best to answer as many problems as you can,

3. Do not to skip any problems,

4. Work carefully and try to get the problems correct,

5. Go to the next page continue to work when finish one page.

6. Stop writing and put a line after the last problem you finish when I say "please stop".

7. Do not worry if you cannot answer all of the problems, because there are more problems in the packet than anyone can do.

Statement for Explicit Timing Sessions for Study 1

1. You will work on the packet of problems for four minutes. After each minute you will be told to stop and you need to put a line after the last problem you finish.

2. Start when I say "please start",

3. Work hard and try your best to answer as many problems as you can,

4. Do not skip any problems,

5. Work carefully and try to get the problems correct,

6. Go to the next page continue to work when finish one page.

7. Stop writing and put a line after the last problem you finish when I say "please stop".

8. Do not worry if you cannot answer all of the problems, because there are more problems in the packet than anyone can do.

Appendix C

Checklist for Experimental Procedures

Checklist for Experimental Procedures

Items list	Yes	No
1. The experimenter tossed a coin to decide the treatment order.		
2. The experimenter gave students correct instruction statement before explicit timing sessions.		
3. The experimenter gave students correct instruction statement before untimed sessions.		
4. The experimenter gave students a clear verbal cue to start and stop untimed sessions.		
5. The experimenter gave students a clear verbal cue to start and stop explicit timing sessions.		
6. The experimenter delivered the correct answer key to students for self-correction.		
7. Students used color pens correcting their incorrect answers.		
8. Students took turns read out loud problems with correct answers when paired up.		
9. The experimenter delivered correct reinforcers to each individual student during untimed sessions.		
10. The experimenter delivered correct reinforcers to each individual student during explicit timing sessions.		

Appendix D

Brief MSWO Data Sheet (Carr, Nicolson, & Higbee; 2000)

Brief MSWO Data Sheet (Carr, Nicolson, & Higbee; 2000)

Student: _____   Assessed By:_____

Dates of assessment: _____

Stimulus Items	Rank by Trial			Sum of 1,2,& 3	Overall Rank (Smallest sum is #1)
	1	2	3		

Student: _____   Assessed By:_____

Dates of assessment: _____

Stimulus Items	Rank by Trial			Sum of 1,2,& 3	Overall Rank (Smallest sum is #1)
	1	2	3		