

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

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 US 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 *Proficient* have tripled since 1990, only 39% of students met this criterion in 2007 (U.S. Department of Education, 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 (Coddling, Shiyko, Russo, Birch, Fanning, & Jaspen, 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 globalized marketplace (Riley, 1997).

In a longitudinal study of mathematics competencies, Jordan, Hanich, and Kaplan (2003) compared two groups of students at the end of 3rd grade. One group of students demonstrated low level 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 the complex mathematics knowledge (Benner, Allor, & Mooney, 2008; Gersten & Chard, 1999; Gersten et al., 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 & Katrina, 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 & Katrina, 2006; Nichols, Rupley, & Rasinski, 2009; Rasinski, 2000), mathematics (Coddling et al., 2007; Gersten & Chard, 1999; Pellegrino, & Goldman, 1987; Poncy et al., 2007), writing (Van Houten, Morrison, Jarvis, & McDonald, 1974; Van Houten, & Parsons, 1975), and even cognitive skills (Fry and Hale's study cited as in Benner et al., 2007). 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., 2007).

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 (Coddling 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; Van Houten, & Parsons, 1975), reading (Cates, & Rhymer, 2006; Van Houten, & Parsons, 1975), and mathematics (Clark, & Rhymer, 2003; Coddling et al., 2007; Miller et al., 1995; Rhymer et al, 1999; Rhymer & Morgan, 2005; Rhymer, et al. 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 is some question about the value of explicit timing with difficult problems. Researchers found when explicit timing was utilized to practice difficult problems, which either involve 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 decreased accuracy level, when students are in the acquisition stage of skill level, where students display low accuracy and low fluency on academic performance (Coddling et al., 2007; Rhymer, et al., 1998). Moreover, when comes to investigating the effects of explicit timing and interspersal assignments on students' perception of assignments, students reported that the assignments were more difficult, and requiring more time and effort to complete under explicit timing condition (Clark, & Rhymer, 2003; Rhymer, & Cates, 2006; Rhymer, & Morgan, 2005), even though they spent less time on completing explicit timing assignments (Rhymer, & Cates, 2006).

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; Robison & Skinner, 2002; Wildmon et al., 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, 2003).

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 number of easy and hard practice problems completed, the number of digits of easy and hard problems completed accurately per minute, the percent of easy and hard problems completed accurately, and on-task behavior.

Research Questions

To what extent do students with learning disabilities complete more easy and hard problems correctly, have a higher rate of digits correct, and higher accuracy of easy and hard problems during explicit timing using interspersed assignments than untimed interspersed assignments?

To what extent do students with learning disabilities have more intervals of on-task classroom 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 area. 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 learning 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, p554). Thus, Van Houten et al. (1975) indicated that each intervention component had contributed to the whole intervention package.

According to previous research (Benner, Allor, & Mooney, 2007; Gersten & Chard, 1999; Pellegrino, & Goldman, 1987; Poncy, Skinner, & Jaspers, 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 (Coddington 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, their age ranged 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 four 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 6th 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 digit 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 three 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 difficult 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 difficult 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 (Neef et al., 1980; Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins, Skinner, & Oliver, 2005; Robison & Skinner, 2002; Wildmon, Skinner, Watson, & Garrett, 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 (Neef et al., 1980; Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins et al., 2005; Robison & 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 (Neef et al., 1980; Cates & Erkfritz, 2007; Cates & Skinner, 2000; Hawkins et al., 2005; Robison & 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 additive interspersal assignments (Cates & Erkfritz, 2007; Cates & Skinner, 2000; Robison & 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, Skinner, Watson, and Garrett (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 number of easy and hard practice problems completed, the number of digits of easy and hard problems completed accurately per minute, the percent of easy and hard problems completed accurately, and on-task behavior.

Method

Participants and Settings

Three students in the 4th grade will participate in this study. All of the participants will be students with learning disabilities and attend math classes in the resource room. All students will perform below grade level on a standardized achievement test such as Woodcock – Johnson III Tests of achievement.

This study will be conducted in a resource room located at a public elementary school in Cache County School District in Utah. Each session will take place at the beginning of math class Monday through Friday. The students will be seated around a curved table facing the experimenter. The students will be engaged for 15 to 20 minutes for each practice session. All sessions will occur during the students' regularly scheduled resource room math class.

Dependent Variables

Dependent variables for this study include percent of easy problems completed, percent of hard problems completed, digits correct per minute for easy problems, digits correct per minute for hard problems, percent of digits correct for easy problem, and percent of digits correct for hard problem. In addition, data will be collected on the percent of intervals of on-task behavior during each timing condition.

The percent of easy problems completed will be calculated by dividing the total number of easy problems by the number of easy problems completed and multiplying by 100. The percent of hard problems completed will be calculated by dividing the total number of hard problems by the number of hard problems completed and multiplying by 100. The digits correct per minute for easy problems is calculated by dividing the total digits correct of easy problems by the total minutes for each session. The percent of digits correct for easy problems will be calculated by dividing the total digits correct by the total digits completed and multiplying by 100. The digits correct per minute and the percent of digits correct for hard problems will be calculated in the same manner as for the easy problems.

The second dependent variable is on-task behavior. On-task behavior occurs, when students sit 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) will be considered off-task.

On-task behavior will be record for each student using a momentary time sampling method with 10-second intervals. A tactile cuing device (a Motive Aider) will be used to prompt the experimenter to record on-task behavior at the end of each 10-

second interval. Observations will rotate student to student sequentially. Each student will be observed for a total of 16 intervals during each experimental session. The experimenter will mark a “+” for on-task behavior and a “-” for off-task behavior on a formatted recording sheet.

Independent Variables

In each experimental session, the experimenter will administer untimed interspersed assignments and explicit timed interspersed assignments alternately. Interspersed assignments will be provided to students in assignment packets. Each packet consists of four worksheets, and each worksheet contains 50 math problems mixed with 25 hard problems and 25 easy problems. Five hard problems will be randomly placed within every two rows among five easy problems. The first worksheet in each packet will always start with three easy problems. All problems will be presented in a vertical format.

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

After both conditions have been implemented, a self-correction procedure will be implemented. Students will be given an answer key to the practice packets, and a colored pen, and will be told to correct their packets. When students find an incorrect answer to a problem, they will cross out the incorrect answer and write the correct answer. Followed by self-correction, students will work with a classmate read out loud problems they have

missed, and for each incorrect problem state the problem and the correct answer. Each student will correct problems with a partner for one minute and then partners will switch roles.

The students then will turn in their practice packets. No information will be provided comparing the number of problems during each condition. Students will receive general feedback, such as, “Good job”, “I like the way you are working hard”. The experimenter will check students’ self-correction results and record students’ scores on a separate recording sheet.

Experimental Design

An alternating treatments design (Cooper, Heron, & Heward, 2007) will be employed to compare the effects of untimed interspersed assignment with explicitly timed interspersed assignments on the performance of easy and hard arithmetic combinations and on-task behavior with students who have learning disabilities. This design is 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 will consist of experimental sessions in which two experimental conditions—explicit timing and untimed practice— will be implemented alternately. The order of experimental conditions will be counterbalanced across sessions by tossing a coin prior to each session to decide which condition will be implemented first.

Baseline. Students who meet the participation requirements will have a pretest session to determine their current accuracy level for two types of math facts, easy problems and hard problems. The pretest worksheets will be selected from Morningside

Mathematics Fluency (Johnson, & Morningside academy, 1993) new (or cumulative) facts worksheets. Each worksheet contains 100 math facts arranged in 10 rows with 10 problems on each row and the problems will be presented in vertical format. For example, the easy problem worksheets might include basic combinations involving all digits (0 – 9) adding or subtracting with 0, or 1 (i.e., $0 + 4$, or $8 - 1$). In contrast, the hard problems worksheets might include addition and subtraction involving number families 3 9 12, 4 4 8, and 4 5 9 (i.e., $9 + 3$, or $8 - 4$). The problems that students complete with at least 85% accuracy will be used as easy problems, and the problems that students complete with less than 70% accuracy will be hard problems shows as figure 1.

Prior to implementing the experimental conditions, two pretests will be administered. In the first pretest students will work on problems that the teacher has indicated they have mastered (easy problems). In the second pretest, students will work on hard problems. The experimenter will orient students to work on the problems from the left to the right across rows of problems. The experimenter will allow students to work on each types of worksheet for four minutes in each pretest session without informing the students that they are timed. The pretest session will be conducted until students score at least 85% or higher on problems identified as mastered and lower than 70% on hard problems for at least three consecutive days. No feedback will be provided on the problems completed. At the end of each session students will be provided a token for working hard which they may exchange for a prize at the end of the week.

Experimental Session. Each experimental session includes two conditions, interspersed untimed practice and interspersed explicit timing, and a self-correction procedure. During untimed practice, packets will be delivered to each student and they

will be 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 will be told when they finish one page, they should go to the next page and continue working. Finally, to stop writing and put a line after the last problem they finish when the experimenter says “please stop”. Also the experimenter will tell the students not to worry if they cannot answer all of the problems, because there are more problems in the packet than anyone can do. The experimenter will time the students for four minutes covertly with a wrist watch.

The explicit timing condition is similar to the untimed condition, except the experimenter will tell the students that they will work on the packet of problems for four minutes. After each minute they will be told to stop and they need to put a line after the last problem they finish. The experimenter will use an audio timer to time students’ performance under this condition.

After completing both conditions, students will be given their self correction packets and a colored pen and will complete their assignment correction routine.

Interscorer Agreement

The experimenter will score all the worksheets initially. To obtain interscorer agreement data, approximately 40% of the worksheets administered will be randomly selected to be rescored by a second scorer independently. Percentage of interscorer agreement will be calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100.

The experimenter will be the initial observer for on-task behavior. A second observer will independently observe on-task behavior use the same manner the experimenter use on 35% of sessions. The interobserver agreement percentage will be calculated by dividing the total number of times that the two observers agree by the number of times agree plus disagree.

Treatment Integrity

Treatment integrity will be assessed by an independent observer during 35% of the sessions. The observer will use a checklist created by the experimenter to collect data on whether the experimenter appropriately implement all the steps on the checklist. The treatment integrity will be calculated by dividing the number of steps checked by the total steps listed and multiplying by 100.

Data Analysis

Data will be analyzed visually using graphs for each student. Sample graphs for one student's performance are provided.

The experimenter anticipates that students will complete more hard problems and easy problems under explicit timing conditions than the untimed conditions as shows in figure1, and figure2. The experimenter anticipates that students will complete more digits correct per minute under explicit timing than the untimed conditions for both easy problems and hard problems, as shows in figure3, and figure4. In addition, the experimenter anticipates students will increasingly complete more problems over the experimental period, thereby producing upward trend data path as figure1 through figure4 shows. As figure5 shows, the experimenter anticipates students will increase their accuracy level throughout the experimental sessions for hard problems. However, the

experimenter anticipates that students' accuracy level for easy problems will stay high across baseline phase and experimental phases as shows in figure 6. The experimenter predicts that students will exhibit higher on-task behavior when working on easy problems than working on hard problems during pretest sessions as show in figure 7. Finally, the experimenter expects that students' on-task behavior will increase under explicit timing condition than untimed condition as shows in figure8.

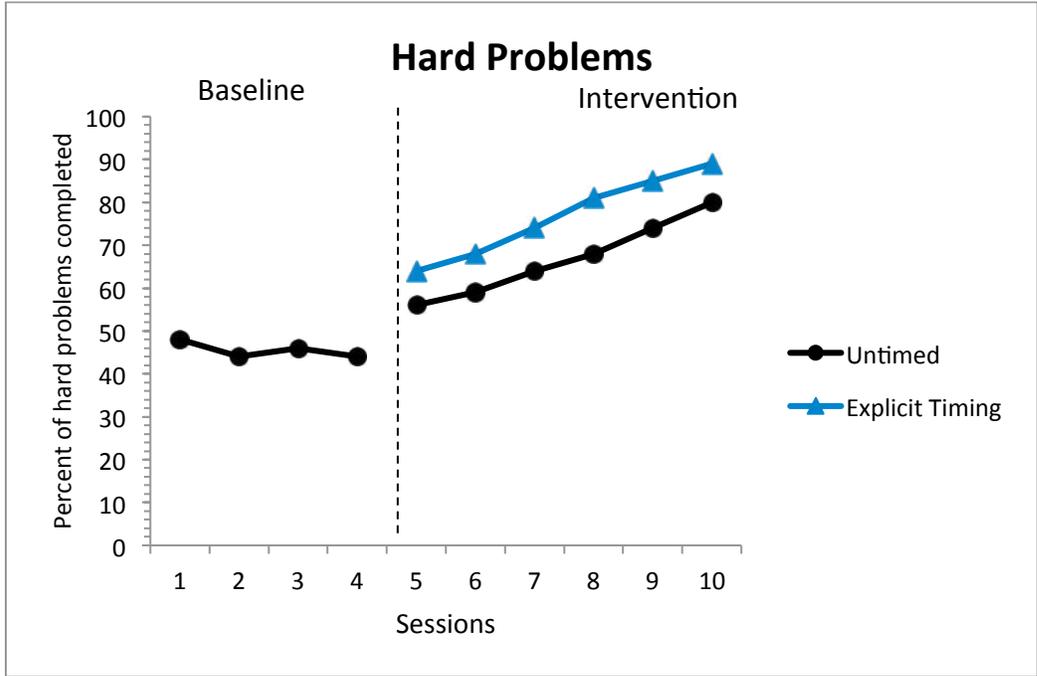


Figure 1. Percent of hard problems completed for student A.

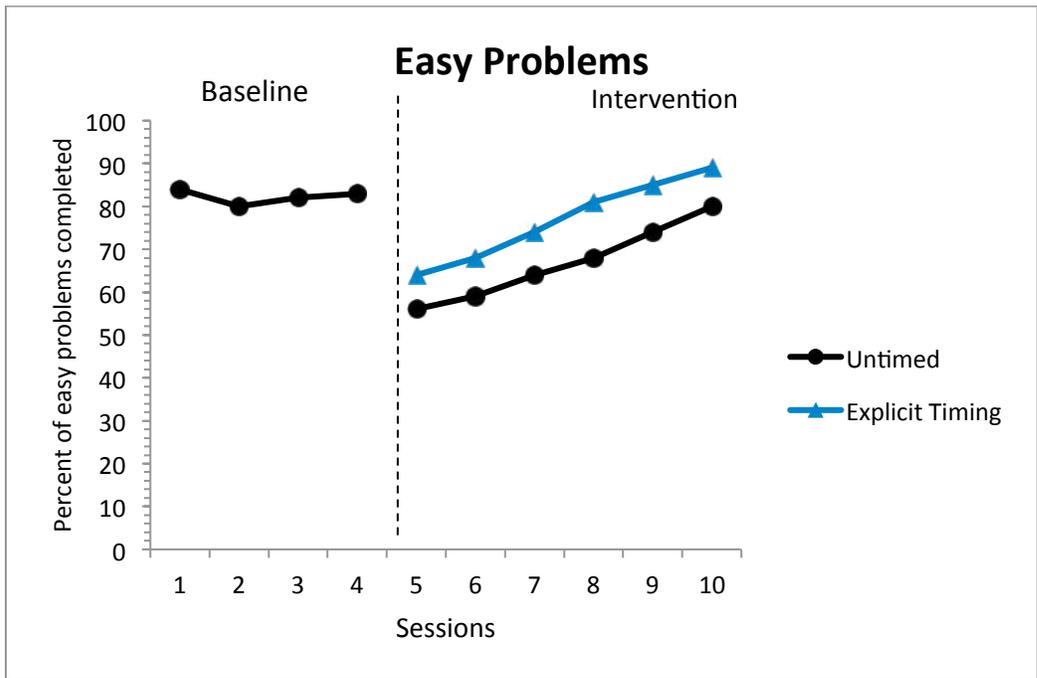


Figure 2. Percent of easy problems completed for student A.

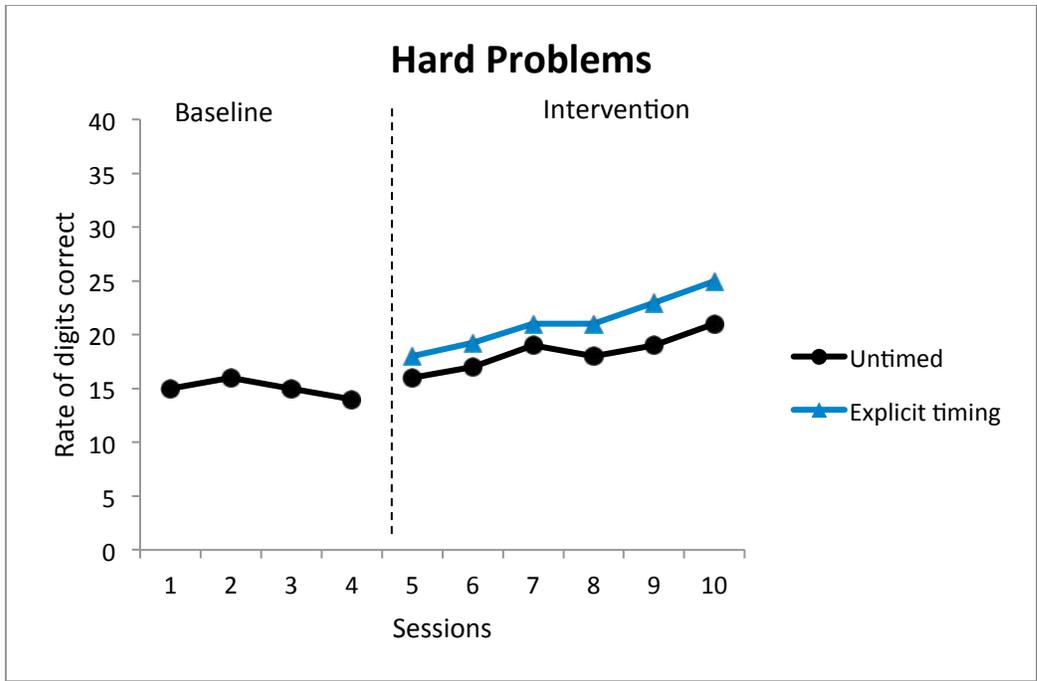


Figure 3. Rate of digits correct of hard problems for student A.

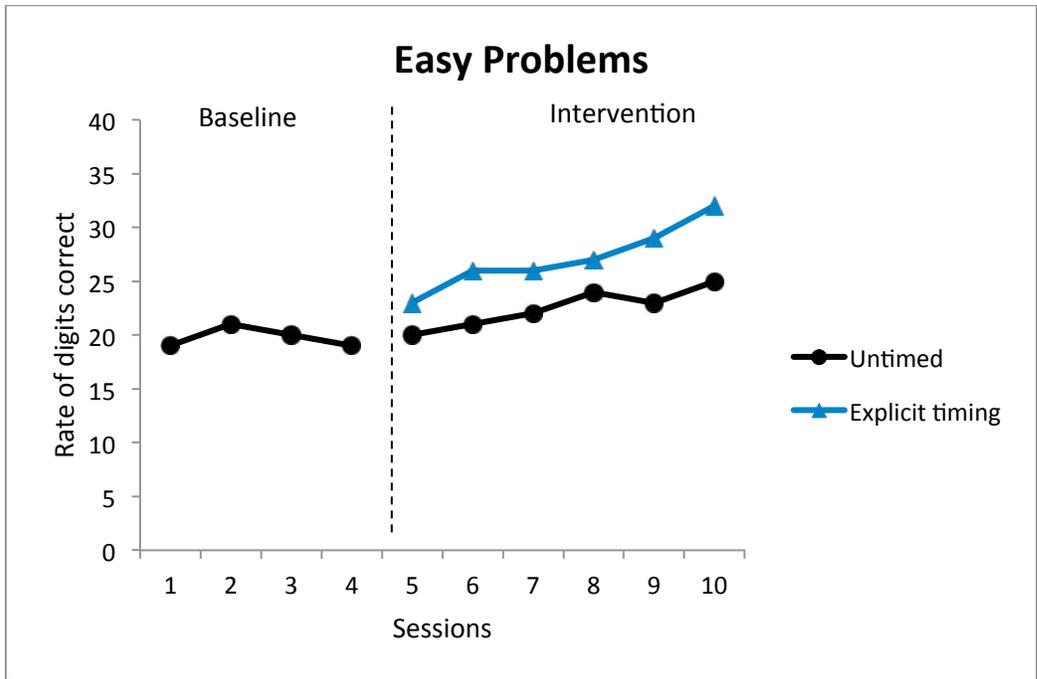


Figure 4. Rate of digits correct of easy problems for student A.

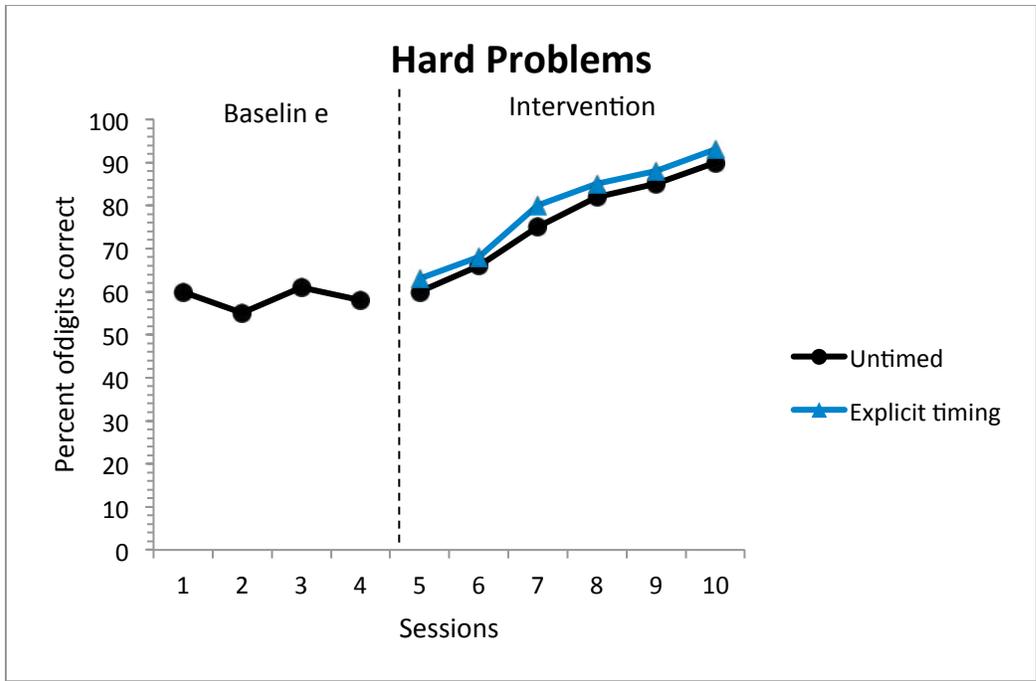


Figure 5. Percent of digits correct of hard problems for student A.

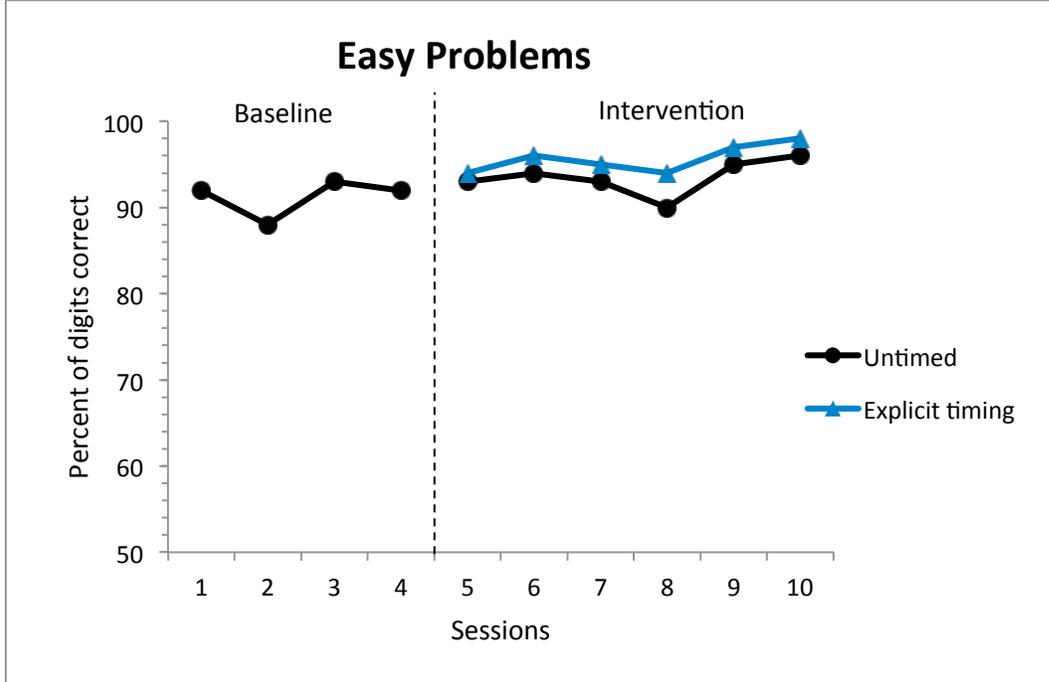


Figure 6. Percent of digits correct of easy problems for student A.

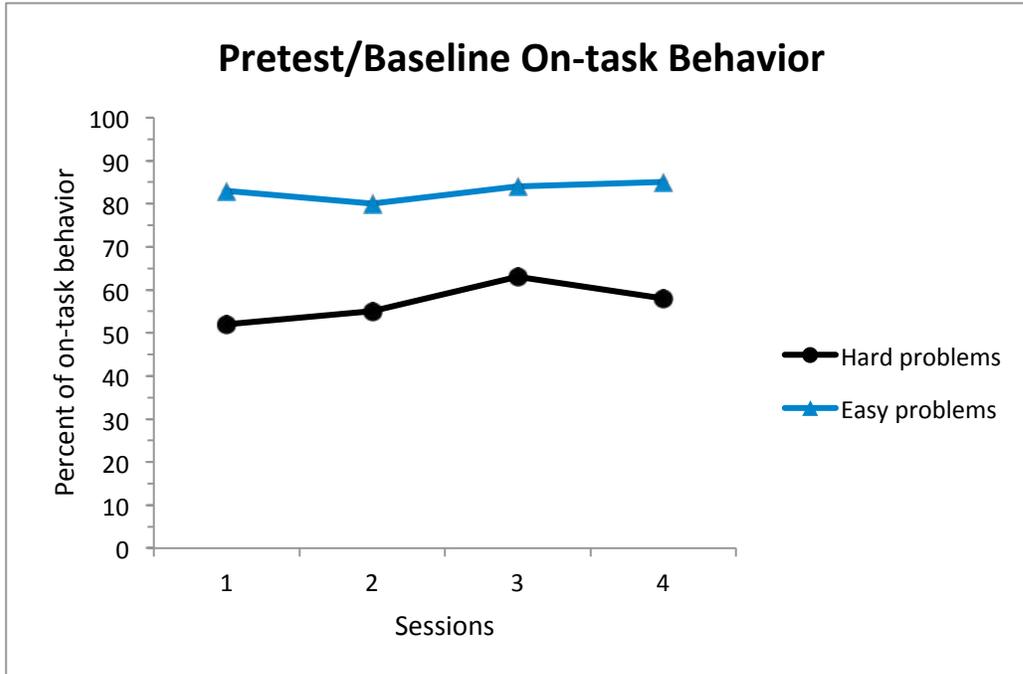


Figure 7. Percent of on-task behavior for student A during pretest sessions.

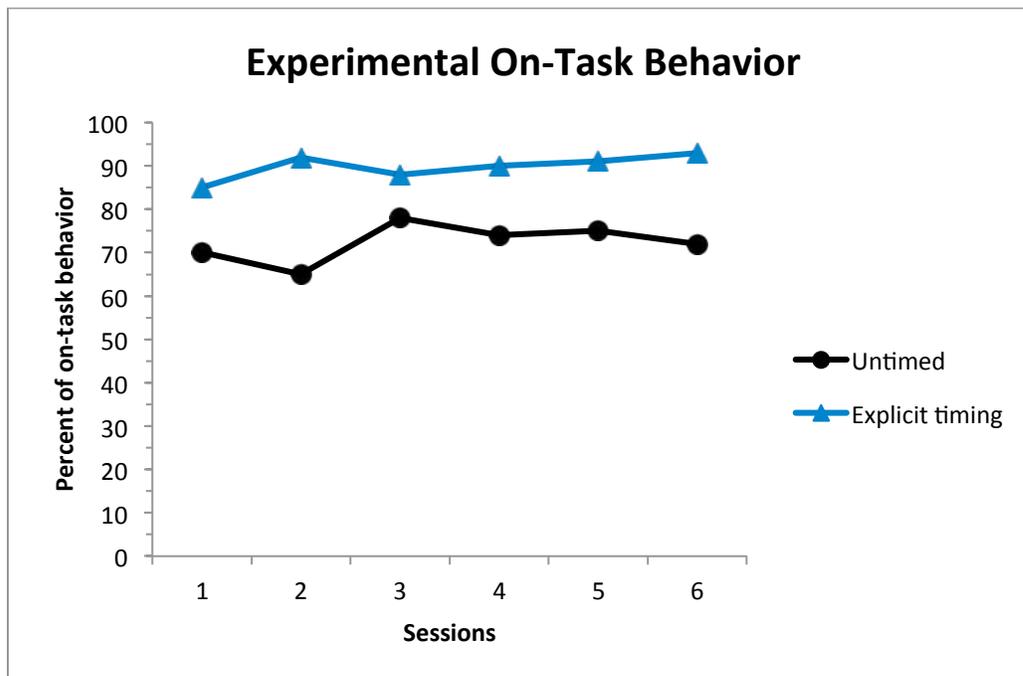


Figure8. Percent of on-task behavior for student A during experimental sessions.

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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. The experimenter supervised students during self-correction procedure.		
8. Students used color pens correcting their incorrect answers.		
9. Students took turns read out loud problems with correct answers when paired up.		

On-task behavior recording sheet

Student Name:				Date:			
Untimed / Explicit timing							
Intervals							
1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
Untimed / Explicit timing							
Intervals							
1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16

Statement for Untimed session

1. Start when the experimenter says “please start”,
2. Work hard and try your best to answer as many problems as you can,
3. 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 session

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.