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The Differential Effects of the DI Flashcard Procedure on Multiplication Facts with a 13-Year-Old Middle School Student with Learning Disabilities

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Abstract: *The purpose of this study was to evaluate the effects of Direct Instruction (DI) flashcard system on the basic multiplication facts of 14-year-old female student with a learning disability. She was enrolled in a middle school math resource room in a large urban school district in the Pacific Northwest. The number of correct math facts was the major dependent variable. A multiple baseline design across problem sets was implemented to assess the effectiveness of the DI flashcard procedure. The overall outcomes indicated an increase in student performance. The issues related to employing DI flashcards were discussed. Three of the five sets of math facts were mastered. However, performance improvements in the other two sets where DI flashcards were not employed were also found.*

Key Words: *Math Facts, DI Flashcards, Learning Disabilities, Multiple Baseline Design, Middle School Student, Low Socio-Economic School, Mathematics*

Introduction

The Differential Effects of the DI Flashcard Procedure on Multiplication Facts with a 13-Year-Old Middle School Student with Learning Disabilities

Students are expected to have their basic multiplication facts memorized by fourth grade. Many factors can hinder such an important accomplishment. Poverty and racial inequality have been shown to have effects on academic achievement. Approximately 75 percent of white students will graduate in four years with a diploma from high school while about 50 percent of Hispanic and black students will graduate within four years of entering high school (Murnane, 2005). These statistics can change if the child is functioning at the average cognitive level as their peers. The cognitive abilities of students at a young age can show how the student will perform later in their academic career, including their graduation from high school (Lloyd, 1978). The *National Assessment of Educational Progress* (NAEP) indicated that a student's math skills help predict future labor outcomes (Murnane, 2005). High schools increasingly are adding a math requirement to graduate high school; most often, the states require a certain level of algebra in order to graduate (Miller & Mercer, 1997). While race can affect a student's ability to be successful in school, learning disabilities may also impact a student's academic career.

Students with learning disabilities make up the largest category of special education under the Individuals with Disabilities Education Act (IDEA) (Zirkel, 2010). Since 2004, strides have been made towards adopting a response-to-intervention (RTI) approach to identify students with learning disabilities (Zirkel, 2010). As of 2010, 12 states in the U.S. have implemented the RTI procedure while other states rely on research methods to discover the academic discrepancies among students. California is ranked high in the United States for its court cases regarding the identification of specific learning disabilities and the state has also expanded regulations regarding the third, research based option to identify learning disabilities (Zirkel, 2010).

A student's skills at recognizing and solving basic multiplication facts is an important cognitive foundation and important sequential skill for topics such as division, multiplication with decimals, finding common factors, and algebra. While rote memorization is helpful, it is also necessary for students to understand the basics behind the problems they are solving. They might know the procedure for solving the problem, but not the underlying principles (McNeil & Alibali, 2000). Miller and Mercer (1993) reported that students who were struggling in math were also performing low in their basic math skills. Also, students with learning disabilities had more difficulty with math than students without learning disabilities (Lerner & Johns, 2009, 2011; Wood, Frank & Wacker, 1996). Finally poor performance in math in the early elementary grades has been associated with later dropping out of school (Lloyd, 1978).

The DI flashcard system for math was first developed by Silbert, Carnine, and Stein, (1981). The flashcard procedures required to implement a DI flashcard procedure include the following. First, a pretest is administered to the student(s). The results from the pretest are then employed to determine which math facts are known and which facts are not known. The teacher then develops sets of math facts. The number of facts per set can vary from anywhere from five to 15. The ratio of know to unknown facts can be adjusted up or down depending on the student. Silbert et al. recommended 12 known facts and three unknown facts per set. Brasch et al. (2008) found that these sets may contain a wide array of know to unknown math facts without any decrement in student performance. Next, the DI flashcards are then placed in a stack or pile by set. The flashcard presented to the student contains the problem without the solution. The problem and solution is on the side of the card seen by the instructor. If the student states the problem and solution correctly with 2 or 3 seconds, he or she receives praise and that flashcard is placed at the bottom of the stack. If the student makes an error, the model, lead, and test error correction procedure (Marchand-Martella, Slocum, & Martella, 2004) is carried out. The teacher models the problem and the correct solution, the student says the problem and solution with the teacher, and finally, the student is presented with the problem and must independently give the correct solution. This has been called the I do, we do, you do procedure. After the student can independent state the fact and its solution correctly three times in a row, this flashcard is then placed at the bottom of the stack. Before that, the error card is placed two or three from the top. This is done to provide students additional practice with their errors (Erbey et al., 2011; Kaufman et al., 2011; Lund et al., 2012; Mann, McLaughlin, Derby, Williams, & Everson, 2013). The instructor tries to teach the student daily. DI flashcards have been successfully implemented in a wide variety of classroom settings (Skarr, Ruwe, Zielinski, Sharp, Williams, & McLaughlin, 2014; Thomas, McLaughlin, & Derby, 2015) as well as in the home (Mann et al., 2114).

The Direct Instruction (DI) flashcard system focuses not only on accuracy but the fluency at which students can learn their math facts (Silbert, 1981). Fluency with math facts has been found to be crucial in students' success in higher mathematical areas (Woodward, 2006). While strategies for solving fundamental mathematical facts are important, fluency is necessary for estimation and mental math but research shows that students that perform at a low academic level and/or students with learning disabilities struggle especially with automaticity, the rate to which they can solve these facts, which correlates with fluency (Woodward, 2006). When incorporating timed practice drills in learning, research has shown it is a successful alternative to strategy instruction, especially for low performing students (Woodward, 2006).

The purpose of this study was to evaluate the effects of DI flashcard system on the basic multiplication facts of middle school low-income student with a learning disability. Another purpose was to replicate our prior research with DI flashcards at the elementary level (Erbey, McLaughlin, Derby, & Everson, 2011, Glover, McLaughlin, Derby, & Gower, 2010; Lund, McLaughlin, Derby, & Everson, 2012) or high school level (Brasch, Williams, & McLaughlin, 2008; Fox-Lopp, McLaughlin, & Hatch, in press; Hayter, Scott, McLaughlin, & Weber, 2007) to a middle school classroom.

Method

Participant and Setting

Our participant was a 13-year-old seventh grade girl at the time the study began. She came from a large family that had moved several times during her schooling. When asked about her preferred activities at school, she indicated that she liked to read and play video games. The student was diagnosed having a severe learning disability, complicated by a three-year absence from attending a public school. The participant performed at a second grade level in math and struggled with multiplication facts. She was in special education classes for reading and math. She spent the rest of the school day attending her general education classes (social studies, science, physical education, and choir). The participant was recommended to the first three authors by one of the special education teachers in the building due to her low performance in math, and the importance of multiplication fact mastery to her future math success.

The study took place in a resource room in a large urban middle school in the Pacific Northwest. The resource room focused on math and served many children with severe behavior disorders. Typically 15-17 students were present each day, during group instruction. In the classroom, daily instruction included an entry task, lesson, individual work and an exit task. The study took place during first period, from 8:45 to 9:46 a.m. on Tuesdays and from 10:10 to 10:55 a.m. on Thursdays. The student was pulled out of her entry task or individual work. She went to time to the back of the room to work with the first three authors. Each session lasted about 15 minutes. This data were collected as part of the course requirements for a degree in special education from a local private university (McLaughlin, B. Williams, R. Williams, Peck, Derby, Bjordahl, & Weber, 1999).

Materials

The materials used in this study included a pre-test, pencils, multiplication flashcards, data sheets, and the post-test. For baseline, the pre-test was composed of the 100 basic multiplication facts. For intervention, the multiplication facts flashcards were placed on 5x7 notecards, with the math fact on the front and the answer on the back. Data collection sheets were used to mark correct and incorrect answers. At the end of data collection, a posttest that was administered was the same as the pre-test to illustrate growth.

Dependent Variables and Measurement

The dependent variables of this study were the number of correct multiplication facts. Correct facts were identified as the participant correctly saying the fact within 3 seconds of the flashcard being presented. Incorrect facts were identified as the participant saying the fact incorrectly, answering correctly after 3 seconds had elapsed, or failing to respond.

An event recording measurement system was used, where the multiplication facts the participant answered as correct and incorrect were recorded. The data collector recorded correct and incorrect responses using a data sheet. Symbols were used to mark (+) correct and (-) for incorrect. The numbers were totaled based on the number of multiplication problems correct in each set (each set contained four multiplication facts). The sets were created through giving the participant a pre-test of 100 basic multiplication facts. From the pre-test, the researchers took the problems that she missed and grouped them according to the guidelines found the in appendix of their Direct Instruction mathematics text (Stein, Kinder, Silbert, & Carnine, 2006).

Experimental Design and Conditions

A multiple baseline design across six sets of multiplication facts (Kazdin, 2011; McLaughlin, 1983) was used to evaluate the effectiveness of the Direct Instruction flashcard system. The decisions to intervene for Set 1 was after baseline showed 0 correct facts. For Sets 2-6, the previous intervened set had to show minimum levels of 4 correct multiplication facts for 2 consecutive sessions.

Baseline. During baseline, the participant took a 5-minute timing of the 100 basic multiplication facts. The student could skip problems if she did not know the answer. The researchers watched as she took the timed test, and recorded any problems that took her more than 3 seconds to complete. No feedback was provided to the participant regarding correct and incorrect answers. However, the participant was assured that it was fine to make mistakes, and that the researchers would use this information to set up their study. Another reason for recording them would be to see her progress at the end of the study. When the session was over, the researchers praised the student for staying on task and answering the multiplication facts quickly. The number of sessions in baseline ranged from 2 to 18 sessions.

DI flashcards (Intervention). The DI flashcard procedure was used in combination with a long-term reward (giving her the flashcards at the end of data collection) to help the participant master her basic multiplication facts. The deck of flashcards was set up with both of mastered and unmastered multiplication facts. The deck was determined (using 39 mastered facts with 24 unmastered facts). At the beginning of the session, the student was tested on all the multiplication facts; data were only taken on the unmastered facts (Sets 1-6). Then flashcards from a specific set would be presented to the participant with a multiplication fact on it. The participant then had to say the answer the multiplication fact. If the answer was correct, the researcher moved it to the back of the pile. If the fact was incorrect, a correction procedure of model and test was used. Then the card was placed 2-3 cards back for review. After the initial presentation, the multiplication fact was reviewed 2 more times, if correct. At the end of each session, the student was tested on all the multiplication facts (Sets 1-6). The student was asked to respond quickly to each multiplication fact presented. Data collection occurred during the tests at the beginning and end of each session. The number of sessions for DI flashcards varied from 0 sessions (Sets 4, 5, and 6) to 16 sessions.

Interobserver Agreement

Interobserver agreement was conducted three times during baseline and seven times during the Direct Instruction flashcard system intervention. One of the authors presented the flashcards to the participant while the other researcher observed the participant. Two authors marked how many correct and incorrect responses independently. After the number of corrects were determined by each data-collector, the percent of inter-observer agreement was calculated. This was done by dividing the smaller total of correct responses recorded by one observer by the larger total of correct responses recorded by the other observer and then multiplying by 100. The percent of inter-observer agreement for the number of correct math facts was 94%. The range was (82% to 100%).

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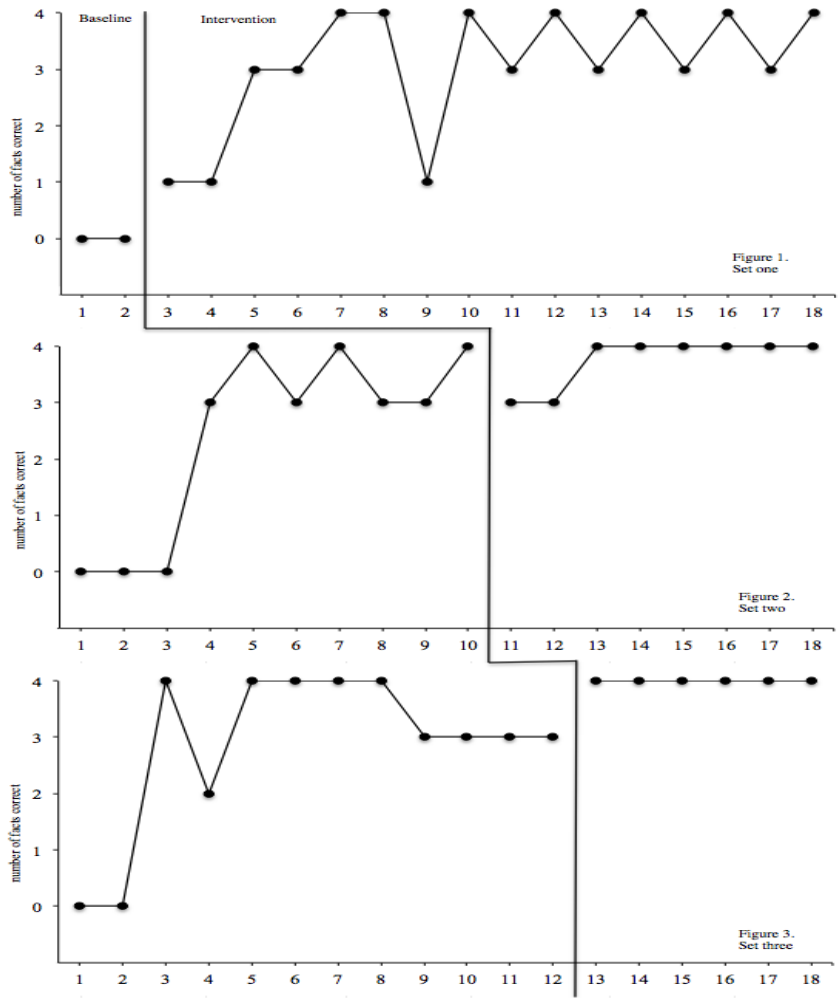
Results

The results of the study of the effectiveness of the DI flashcard procedure are presented in Figure 1. An increase in the number of facts correct from baseline was found for the first three sets. Baseline for Set 1 was 0.0. When DI flashcards were implemented an increase in performance was found (*M* = 3.1; range 1 to 4 correct). For Set 2, and increase after the third day of baseline was found. The overall mean for baseline was 2.4. When DI flashcards were employed, the overall mean for Set 2 increased to 3.7 problems correct. For Set 3, an increase in daily performance took place after the second session of baseline. The overall mean for baseline was 2.5 with a range of 0 to 4). When DI flashcards were in effect, the participant's performance was perfect for the last six sessions (*M* = 4.0 correct)



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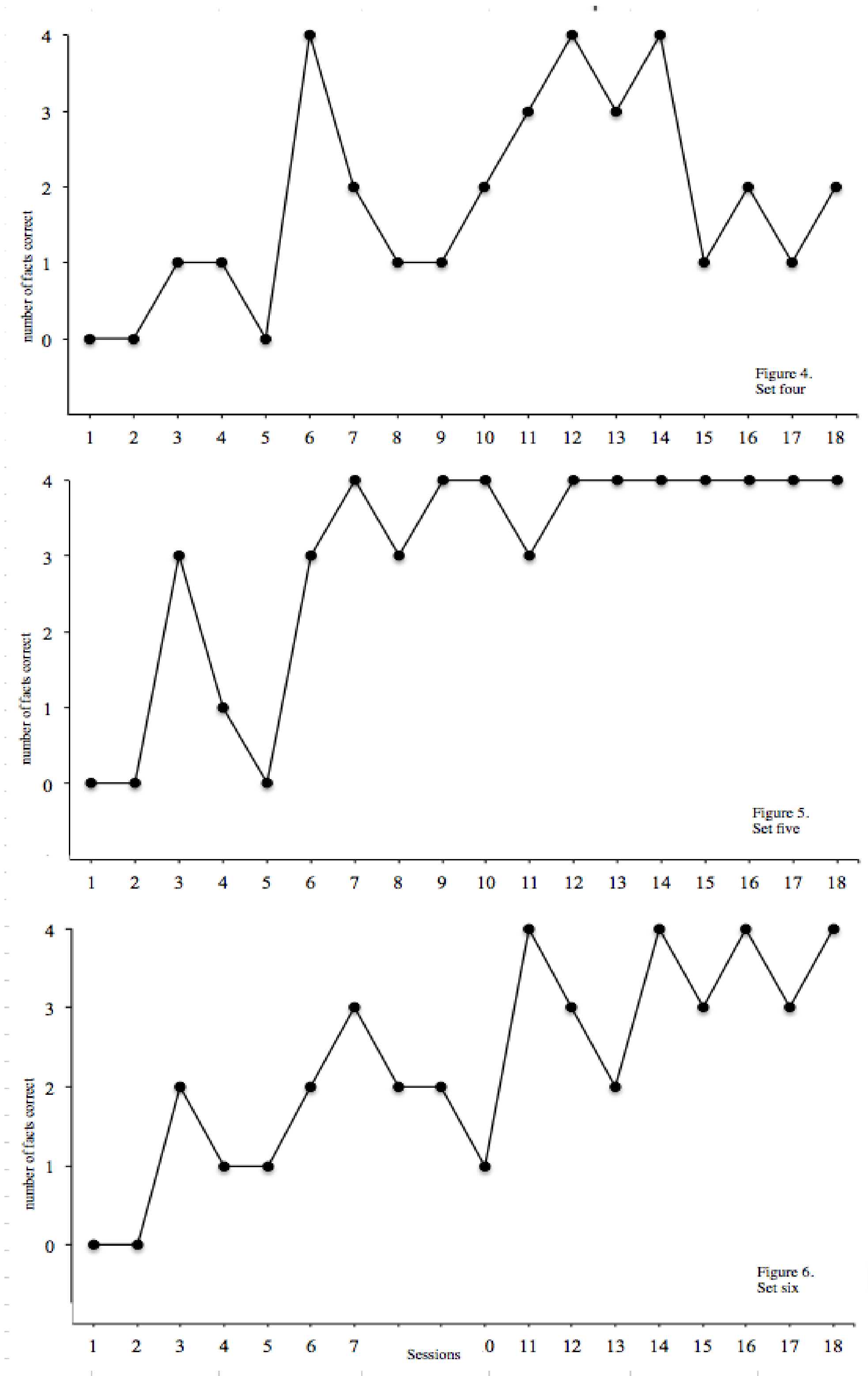

Figure 1. The number correct for baseline and DI flashcards

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The DI flashcard procedure was never implemented with Sets 4 through 6. For baseline the number correct was variable ranging from 0 to 4. However, for Set 5, the student's performance was perfect for the last seven sessions. Set 6 showed in increasing but variable trend during baseline (*M* = 2.3 words with a range of 0 to 4 problems correct.

Discussion

The data clearly shows an increase in the number of multiplication facts mastered. However, the data were slow to show a consistent trend for mastery for the Set 1. This delayed the implementation of DI flashcards for our other sets. Prior to the intervention, the participant scored 33 out of 100 on the pretest administered by the first three authors. We then chose multiplication facts that would be the next sequential skill (several 2's and 5's). This way the she could learn the most basic facts (and the most frequently used) and the classroom teacher would continue to work on the more difficult facts.

The DI flashcard procedure was socially significant (Wolf, 1978) for the participant. Before the study, she would take over 5 seconds to answer her basic multiplication facts and it greatly reduced her academic performance in class. The participant was often unable to complete assigned entry task/classwork or took extra time to do so. As the DI flashcard procedure intervention progressed, we noticed a quicker response time for the multiplication facts when she responded orally. Unfortunately, she continued to struggle with generalizing this knowledge to answering written multiplication facts.

While the DI flashcard procedure was somewhat effective, it was also practical in terms of time, money, and effort. During the study, the researchers found that the participant enjoyed learning her multiplication facts. The first three authors did spend about $3.00 on rewards and 2 dollars for a complete set of 100 basic multiplication facts. When data collection was over, she was allowed to keep the complete set of multiplication facts.

Strengths of the study include: consistent participant attendance, support from both classroom teachers, as well as the nature of the classroom (the student felt comfortable being pulled out of everyday instruction). Weaknesses of the study were the lack of generalization to written facts and the inconsistent data trends. If the study was to be conducted again, the researchers suggest focusing not only on memorizing the facts but on teaching the connection between knowing/ recognizing the fact and being able to output it in a different setting.

There were some limitations in the present research. The study took place over a relatively short period of time. The researchers spent less than 5 hours (total) with the student because the procedure lasted only about five minutes session. The change in performance for problems in Sets 4 through 6 can be viewed as a concern. Her performance should have remained low during the baseline for these sets. Therefore, the efficacy of the DI flashcard procedures can be viewed with some caution.

The present outcomes provide a partial replication of our research employing DI flashcards (Erbey et al., 2012; Kaufman et al., 2011; Lund et al., 2012; Mann et al., 2013; Skarr, Ruwe, Zielinski, Sharp, & McLaughlin, 2014) at the elementary school level. The present research also replicates our research employing DI flashcards with middle school students with moderate disabilities (Cole et al., 2013; Ruwe et al., 2011). Clearly, a longer analyses as well as a replication by another research group are needed.

The special education teacher already uses a similar procedure in her classroom, and she indicated she will continue to use the procedures we implemented during the intervention portion of this case report. The researchers also gave the student her own set of 100 basic multiplication facts because she expressed interest in learning. The first three authors are quite confident that she will work independently to gain mastery with her remaining math facts.

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