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The Effects of a Modified Direct Instruction Flashcard System on a 14 Year-Old-Student with Learning Behavioral Issues Enrolled in a Behavior Intervention Classroom

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Peer Review

This work has undergone a double-blind review by a minimum of two faculty members from institutions of higher learning from around the world. The faculty reviewers have expertise in disciplines closely related to those represented by this work. If possible, the work was also reviewed by undergraduates in collaboration with the faculty reviewers.

Abstract

The purpose of this study was to evaluate the effects of a Direct Instruction (DI) flashcard system on the mastery of the multiplication facts by a 14-year-old boy with learning and behavioral issues. The participant attended a low-income high school located in a large urban area in the Pacific Northwest. A changing criterion design was employed to evaluate the efficacy of DI flashcards. When DI flashcards were employed, the performance increased and the participant met or was close to criterion for each criterion ceiling. The DI flashcard procedure was easy to implement and evaluate, and the current paper includes suggestions for additional research with DI flashcards at the high school level.

Keywords

multiplication, LD, behavior disorders, math facts, elementary student, secondary student, DI flashcards, changing criterion design

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INTRODUCTION

The world we live in today is full of technological advances that make our daily lives easier. Calculators solve complicated math problems with little to no effort, and electronic tills at the grocery store give back exact change at the push of a button. Many people feel that these modern conveniences negate the need to learn math facts. However, research has shown that students who know basic math facts can solve complicated math problems and are also more able to understand higher mathematical concepts (Stein, Kinder, Silbert, & Carnine, 2006). Finally, if a student does not have adequate math skills, this deficit has been linked to dropping out of school (Balfanz & Byrnes, 2006; Balfanz, Herzog, & MacIver, 2007; Lloyd, 1978) and later employment issues (Murnane, 2007; Murnane, Willett, Duhaldeborde, & Tyler, 2000; Murnane, Willett, & Levy, 1995).

Approximately five percent of the school-age population may be identified with a learning disability, which often co-occur with social, emotional and behavioral disorders (Lerner & Johns, 2011). Approximately five to nine percent of the same population identify specifically with a mathematics deficiency (Geary & Hoard, 2003; Heward, 2013). For more than 20 years, math disabilities have been recognized as a type of learning disability, as evidenced by the inclusion of mathematics in the second most common area where students have learning disabilities (Bryant, Bryant, & Hammill, 2007; Heward, 2013).

Poor mathematics skills have been associated with life-long difficulties both in school and in the workplace. With many students leaving high school with poor mathematical skills, their employment, income, and overall work performance can be affected negatively (Murname, 2007). The ability to understand basic calculation skills lays the foundation for a child's entire academic career and how he or she uses rational problem solving skills when working with numbers. Similarly, fact memorization may been seen as drudgery by students, but the ability to quickly and accurately respond when presented with various math facts is the next step in mathematical instruction and allows students to quickly compute a math fact without taking an extra ten seconds to type it into a calculator. While a calculator is allowed and, often times, provided in some classroom situations, the student may encounter others where a calculator is either prohibited or not immediately on hand. Outside of the classroom, those unable to memorize their multiplication facts will not be able to determine the amount of a discount on an item in a store, or be unable to determine if they have been overcharged by accident. Even if a calculator is available, it is subject to human error. If one does not know their basic math facts, they will not recognize an error in computation, or simply in hitting the wrong button.

There is a large empirical evidence base supporting the use of less technologically sophisticated tools to teach students basic math facts. McLaughlin and colleagues (McLaughlin et al., 1999) have evaluated courses that allow our candidates to examine the efficacy of a straightforward procedure labeled Direct Instruction (DI) flashcards. Silbert, Carnine, and Stein first suggested the use of DI flashcards for use in the classroom in 1981. It was developed to teach math facts to struggling students. Since that time, various forms of DI flashcards have been employed to improve student performance in both general as well as special education classrooms (Skarr et al., 2014). DI flashcards have been implemented in preschool special education classrooms (Fitting, McLaughlin, Derby, & Blecher,

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2013; Mangundayo, McLaughlin, Williams, & Toone, 2013), resource room settings (Glover, McLaughlin, Derby, & Gower, 2010; Kaufman, McLaughlin, Derby, & Waco, 2011; Lund, McLaughlin, Neyman, & Everson, 2012), self-contained elementary, middle and high school classrooms (Cole, McLaughlin, Derby, & Johnson, 2012; Crowley, McLaughlin, & Kahn, 2013; Doll, McLaughlin, Neyman, & Schuler, 2013; Pierce, McLaughlin, Neyman, & King, 2013; Ruwe, McLaughlin, Derby, & Johnson, 2011) as well as in the home (Mann, McLaughlin, Williams, Derby, & Everson, 2012). DI flashcards have been employed across a wide range of students and disability designations. These have ranged from students with learning disabilities (Erbey, McLaughlin, Derby, & Everson, 2011; Lund, McLaughlin, Derby, & Everson, 2012) to students with autism (Crowley, McLaughlin, & Kahn, 2013).

Briefly, employing DI flashcards in math involves the following: (a) first a pretest is administered to determine which math problems the student knows or does not know; (b) next these data are used to develop stacks containing both known and unknown facts; (c) the ratio of known to unknown facts can be 12 known to 3 unknown or any combination that allows the student to be successful; (d) the teacher or tutor presents the flashcards one at a time and tallies both corrects and error cards while the student has to say the fact as well as the solution with 2 or 4 seconds; (e) if a student misses a math fact, then a model lead and test error correction procedure (Marchand-Martella, Slocum, & Martella, 2004) is instituted; (f) this error drill involves the teacher saying the fact and answer, the student and teacher saying the fact and its solution, and finally the student being tested on the error fact; (g) if an error is made, this process is completed until the student can correctly state the fact and its solution; (h) this card is placed two or three cards from the top to provide addition error correction; and (i) when the student can state the fact and its solution three consecutive times, the card is placed at the bottom of the stack. Teachers have employed these procedures with a wide range of known to unknown facts (Brasch, Williams, & McLaughlin, 2008).

We decided to investigate if a DI flashcard system could increase our participant's skills with his multiplication facts**.** Another purpose was to extend and replicate prior research (Doll et al., 2013) using DI flashcards in a special education high school classroom.

MATERIALS AND METHODS

Participant and Setting

The participant was a 14-year-old male in the ninth grade. He was diagnosed with a learning disability. In addition, he was viewed as physically and verbally aggressive when frustrated or provoked by the school staff. Due to his anger management issues, he was placed in a behavior intervention (BI) classroom in the Pacific Northwest. This classroom setting has been employed in other undergraduate (Carter, McLaughlin, Derby, Schuler, & Everman, 2011) and graduate research (Doll et al., 2013), and serves as both a student teacher placement as well as a practicum site for teacher education candidates completing their endorsement in special education.

The participant's present level of performance was a sixth-grade level. The participant's teacher and the first two authors selected the participant for this project. The study began in the spring of 2014. The participant was assessed in the school's computer lab. Data were collected every Monday and Wednesday around 1:00 p.m. in 15-20 minute increments for five weeks. The authors alternated between

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administering the intervention and collecting data. The classroom research documented and evaluated in this paper is approved as standard classroom practice by the Institutional Review Board.

Materials

There were very few materials needed in this project. The authors developed and employed two sets of homemade index flashcards. These flashcards had numbers handwritten with a black sharpie. The flashcards were 40 math facts from *Designing Effective Mathematics Instruction: A Direct Instruction Approach* (Stein, Kinder, Silbert, & Carnine, 2006). A data collection sheet and pens were also utilized. The student was presented a Reese's Fast Break as a reward for completing each session. These were presented as part of an ongoing token reinforcement program developed and implemented in the high school classroom.

Dependent Variable and Measurement

Math facts used in the current study were derived from page 81 in *Designing Effective Mathematics Instruction: A Direct Instruction Approach* (Stein et al., 2006). Sets 1 and 2 consisted of five different flashcards, and Set 3 included six different flashcards. The unknown flashcards in the sets were determined by the problems the student missed on the pre-test and in baseline. Set 1 consisted of 6x5, 7x5, 8x5, 9x5, and 5x5 and 11 facts that our participant answered correctly on the pretest or in baseline. Set 2 consisted of (x7 math facts) and 11 additional facts that our participant said correctly on the pre-test and in baseline. Set 3 consisted of x6 math facts. The dependent variable was the number of correct responses when the participant was presented with all the multiplication problems in all three sets. A response was marked as correct if the participant verbally stated the correct value of the multiplication problem within two seconds of being presented a flashcard. If any other answer, an answer that was said after two seconds, or if no answer was provided, it was marked as incorrect. In the event that the participant incorrectly answered the problem, the response was counted as correct only if he immediately self-corrected. The total number of facts for each session totaled 40 based on an adjusted ratio of known to unknown facts (13 total facts in Set 1, 13 total facts in Set 2, and 14 total facts for Set 3).

Experimental Design and Conditions

A changing criterion design across three combined sets of flashcards was implemented to evaluate the effectiveness of our DI flashcard procedures (Kazdin, 2011; McLaughlin, 1983). After the pretest was administered, the first two authors conducted baseline testing across all sets. These data were collected after every session by either the first or second author. During baseline, if a response was correct, the flashcard went to the back of the stack. If the response was incorrect, the flashcard was set down on the table.

Pre-test. The participant was given a pre-test to determine what skills needed to be taught. The pre-test was a pre-prepared worksheet of multiplication facts, prepared by the participant's classroom teacher. The pretest was administered by the second author. The participant was given a 5-minute time limit to complete the pre-test.

Baseline. During baseline, the author would hold the deck of flashcards in front of the participant. The participant was instructed to read the whole problem and recite the answer in two seconds or less. This would count as a correct response and a check would be tallied on the data sheet for that problem. If it was answered incorrectly, not at all, or not within the time frame, it was marked with an x. Baseline was in effect for three sessions for all three sets of flashcards.

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DI flashcards. Three sets of multiplication facts were written on flashcards for the participant. At the beginning of every session, either the first or the second author presented all of the flashcards to the participant and recorded the outcome on the data sheet. These cards were placed in a particular order that coincided with the order of multiplication facts on the data sheet. Then, the author administering the intervention would present the cards that were a part of the flashcard intervention procedure. These sets were not placed in any particular order; however, there was a 4:1 ratio of previously mastered cards mixed in with the cards that needed to be learned. This again made a total of 40 cards per session. If the student answered a flashcard incorrectly, the author administering the flashcards would correct the answer, ask the student to say the answer aloud, and prompt the student to read the full problem, including the answer. The card was placed three cards back from the front, and the student had to answer it correctly three more times in order for it to be placed in the back of the deck. The author administering the intervention was encouraged to give verbal feedback and praise, however the praise statements were modified over time so that the student wouldn't feel patronized. Once the student had answered all of the flashcards, the session was over. The authors would move on to the next set when our participant had mastered all the problems in Set 1 during the initial flashcard review. These data were gathered at the beginning of the session. The DI flashcard procedure was in effect for three different criteria and for a total of 11 sessions.

Reliability of Measurement

Interobserver agreement was taken for most sessions but one in baseline as well as during DI flashcards conditions. When reliability was being taken during a session, the author administering the flashcard procedure would mark on the reliability sheet after each question was answered while the other author would mark the correct and incorrect responses as usual on the data sheet. This was completed so neither author could see what the other had scored. When the session was over, the reliability sheet was compared with the data sheet. The number of agreements (both observers scoring the problem in the same manner) was divided by the number of agreements plus disagreements (a difference in scoring by either author) and multiplied by 100. Interobserver agreement for all measures was 100%.

RESULTS

The number of correct math facts by our participant during baseline and DI flashcards are displayed in Figure 1. For baseline, the number of math facts that were correct ranged from 12 to 14 with an average of 13.0 (SD = 0.6). When the DI flashcards were employed with a criterion of 25 corrects, the number of correct facts increased (*M* = 25.3; range 20-27; SD = 4.7). When the criterion was increased to 30, our participant's performance was near or just below that criterion (*M* = 29.0; range 27-34; SD = 2.8). When the last criterion was increased to 35, the participant's performance was below that criterion while the last session was above that criterion (*M* = 32.5; range 28-37; SD = 6.4).

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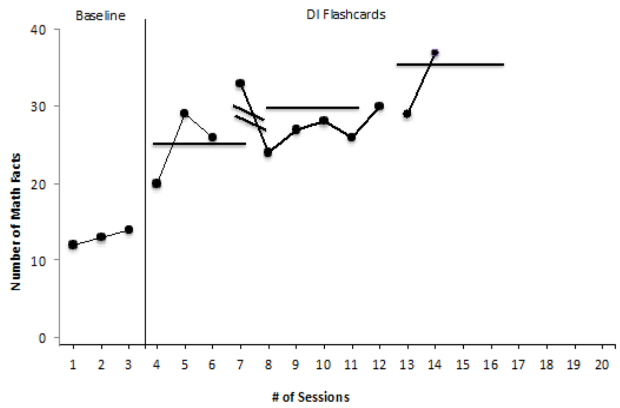

Figure 1. Number of correct math facts, out of a possible 40, during baseline and DI flashcards with the three criterion changes.

DISCUSSION

The DI flashcard system resulted in multiple areas of improvement for the student. The total number of math facts mastered increased considerably by the final session.

The increase in mastered math facts after the flashcard system was implemented could indicate that the student was not receiving enough practice at these facts throughout the school day. As a freshman in high school studying pre-algebra, the student's math practice does not generally include working on multiplication. Hence, attention to these facts for an additional 40 minutes a week provided the practice he needed to increase his skills. Also, he was receiving one-on-one instruction, and smaller classes have been associated with improved performance in math (Finn, Gerber, & Boyd-Zaharias, 2005). Anecdotally, at times when he appeared frustrated, the participant had to be reminded that he was making good progress and that a reward was available after the session was concluded. Often, he displayed a lack of wanting to participate in the DI flashcard procedure. However, over time, we noted that the participant exhibited a more positive and hardworking attitude. With each session, his confidence and ability to respond quickly to the flashcards improved. We also noticed his ability to self-correct simple mistakes improved. This resulted in a reduction of the amount of time spent practicing each new set. The reward at the end of each session helped him stay on track during the practice time despite some frustration, leading to an increased focus throughout the session.

As can be seen in Figure 1, the variable performance increasing trends occurred throughout data collection. While the amount of correctly answered facts increased over the course of the entire intervention, the number correct varied a great deal during the process. We feel this is attributable to sessions missed due to the spring breaks of the participant and first two authors (denoted as double-lines in the figure). In addition, there was a week of student conferences that occurred during the usual time when the first two authors worked with the participant. Conclusions about improvements observed using DI flashcards should also be tempered by the increasing trend in performance observed at baseline.

An apparent strength of the study was that the flashcard system facilitated an age appropriate method to help a struggling student develop his knowledge of math facts. The system could be modified so that praise was not patronizing and served to encourage hard work during intervention. Another strength lied in the isolated area where practice took place, providing a supportive and nonthreatening environment. Finally, the reward provided at the end of each session was based on his effort rather than the correct answers given; this was emphasized to the student and succeeded in preventing discouragement and frustration. The participant showed that increased exposure and practice with other facts also increased his correct responses in between sets, before the intervention began. This

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showed the flashcard practice and baseline data were successfully based on the student's ability to master other facts before direct intervention with those facts. The present outcomes replicate previous research at the elementary school level for students with behavior disorders (Pierce et al., 2012). They also replicate and extend research at the middle school level (Cole et al., 2012; Ruwe et al., 2011). The finding that math facts can be taught using DI flashcards at the high school level also replicates prior work with students with severe behavior disorders (Brash et al., 2008). Finally, the intervention method proved practical, affordable, and produced results equivalent to the amount of effort of our participant.

A weakness to the study was the researchers' inability to meet with the student more often. Both researchers agreed that if sessions had been more frequent throughout the week, the participant's progress could have been more dramatic. An adjustment to remedy this while improving student learning could be to revisit the set of flashcards that included all 40 facts after intervention of that day's set. After a brief break, the student would have the chance to go through the flashcards and practice what they had just learned, as well as work on retaining what they had previously mastered. Another weakness included the time of the sessions, which always occurred during the second part of the day. Had the sessions occurred before the lunch hour or earlier in the morning when the student was less tired and more engaged, more progress might have been made. Finally, if the length of the research could have been similar to that we have employed in prior work (Crowley et al., 2013; Mangundayo et al., 2013; Pierce et al., 2012). At present, no plans were made to further the study or continue intervention in the participants classroom.

Overall, the student's ability to master necessary multiplication facts allowed for more confidence with math facts when completing other homework. He became more efficient in completing his problems, promoting a happier attitude and an increased eagerness to work with the researchers each session. As a student with learning disabilities and behavior issues as a result of academic frustration, these results may be socially significant in that they addressed deficits in both areas. The study was also practical and efficient, and could easily be replicated in this and other classrooms by a classroom aid or student teacher with brief training.

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