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THE EFFECTS OF FLASHCARDS AND A MATH RACETRACK ON MULTIPLICATION FACTS FOR THREE RURAL ELEMENTARY STUDENTS AT- RISK FOR SCHOOL FAILURE‡‡‡‡

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ABSTRACT

The purpose of the present research was to examine the effectiveness of DI flashcards and a math racetrack procedure with basic math facts. Three students at-risk for school failure and enrolled in a rural elementary school, served as participants. Data were gathered for both corrects and errors both orally and in writing. Fluency measures were gathered from the one-minute timed test as the end of each session. The overall results indicated that all three students improved their performance. Also, each student could complete more problems correctly per minute on their timed tests. Pre and posttest scores for math facts also improved. The development, management, and implementation of these procedures were discussed.

Keywords: math facts, DI flashcards, math racetrack, timing, fluency, rural elementary school, multiple-baseline design; rural education, at-risk students

INTRODUCTION

Knowing the multiplication facts continues to be a fundamental and critical part of the elementary math curriculum. Fluency in basic multiplication facts is imperative for success of students in K-12 education and beyond (Johnson &Layng 1994; Stein, Kinder, Silbert&Carnine, 2006). The study of mathematics is important not only for the foundation for basic computational skills, but also for developing abstract and critical thinking. Success in the job market, in school and the management of everyday life all rely on having good math skills. Despite these requirements that schools have placed on students, thousands of students have struggled to learn and retain the required math benchmarks required for their grade level. This is a continuing issue and causes great concern for parents, teachers and school policy makers (Stein et al., 2006). The academic outcomes of struggling students and other educational issues led many in congress to pass The No Child Left Behind Act of 2001 (United States Congress, 2002). This act has had effects of on both students and teachers making both accountable for their overall performance (Altwerger, Arya, Jordan, & Martens 2004).

Curico (1999) indicated that learning basic math facts may not a prerequisite for solving problems, but learning facts becomes a necessity to solve problems that are meaningful, relevant, and of interest to the student. Curio also suggests that when schools and students try to get around learning the facts, the results are quite bad. Difficulties in learning math are common in both special educations as well as in regular education classes (Garnett, 1998). Without mastery of basic multiplication facts, students may well struggle their entire school career (Lloyd, 1978; Stein et al., 2006). Also, they will have an increased probability of dropping out of school and being incapable of functioning productively in today's global economy (Lerner & Johns, 2008). The basic skills are fostered in the primary years of

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education and are critical pre-skills for more advanced math concepts. Students who ultimately struggle with mathematics often react by decreasing effort, having lower self-esteem, or simply give up not wanting to do math at all. Unfortunately, math underachievement poses major problems for students in general education classrooms (Heward, 2013). This deficiency could cause student's to be at-risk for significant problems related to academic success and cause the need for special education services. The current problem with at-risk math students is that most don't qualify for services and without intervention there is a greater probability of weak academic performance (Greenwood, 1991).

Learning disabilities are a group of disorders manifested by difficulties in listening, thinking, speaking, reading, writing, spelling, or doing mathematical calculations (Heward, 2013). Students with disabilities are often hard to identify and differentiate from students who are underachievers or unmotivated that might contribute to other factors (Lerner & Johns, 2008, 2011). Several factors may explain the poor mathematical performance among American students. Textbooks and other educational materials are poorly designed, and tend to fail in developing the critical steps necessary for developing a complete math understanding of critical concept (Stood &Jitendra, 2007). There is no room for a student to fall behind, and once a student is behind it is hard for the teacher to find the time to bring that student up to level. Instructional models for teaching need to highlight clear and well-defined lesson plans, also making time for small group instruction. Direct Instruction has been found to be the most effective and successful procedure to teach students with disabilities basic math facts (Kroesbergen&VanLuit, 2003).

Direct Instruction flashcard system has been shown to be successful in improving student performance with basic math facts (Brasch, Williams, & McLaughlin, 2008). In addition, it was one of the three methods suggested by Stein, Carnine, and Silbert (1981) to teach basic skills in math. With this procedure, flashcards are presented to students. If the student is correct, then they are presented the next flashcard. If the student makes an error, the teacher verbally models the problem and its answer. The student is then required to say the problem and answer. The teacher then presents the flashcard again. If the student is correct, the card is placed three to five cards back so it will appear quickly. If the student makes an error, again, the model, lead, and test procedure is carried out. After the stack of flashcards has been presented, the student is required to take a test, either orally or in writing. Data from this test is typically graphed and the student moves to another activity. Flashcards can be implemented in almost any setting and teaches specific skills quickly and easily (Van Houten&Rolider, 1989; Glover, McLaughlin, Derby, & Gower, 2010). Direct Instruction flashcard systems (Bishop, McLaughlin, & Derby, 2011; Brasch et al., 2008; Hayter, Scott, McLaughlin, & Weber, 2007; Sante, McLaughlin, & Weber, 2001; Silbert et al., 1981) has shown promising results and some attention in the peer reviewed literature. In Direct Instruction flashcard system, it has been shown that students that are taught using this teaching method have performed higher on post-test compared with students who are taught using more traditional methods (Sindelar& Wilson, 1991). The intervention consisted of presenting the student with pre-determined sets of targets basic multiplication math facts in a flashcard format. The student had to state the problem and answer correctly within the two seconds for the fact to be considered mastered.

In conjunction with DI flashcards, a math racetrack was also employed to teach mastery of basic multiplication math facts. A math racetrack is an adapted form of reading racetrack, using math facts instead of letters of sight words (Beveridge, Weber, & McLaughlin, 2006). This game-like procedure has received attention in the literature in reading (Anthony, Rinaldi, Hern, McLaughlin, 1997; Erbey, McLaughlin, Derby, & Everson, 2011; Rinaldi& McLaughlin, 1996; Rinaldi, Sells, & McLaughlin, 1997; McLaughlin et al., 2009; Ruwe, McLaughlin, Derby, & Johnson, 2011), math (Beveridge et al., 2006), letter sounds, (Travis, McLaughlin, Derby, Dolliver, &Carosella, 2011), colors with preschoolers (Herberg, McLaughlin, Derby, & Williams, 2011) and spelling (Arkoosh, Weber, & McLaughlin, 2009; McLaughlin, Weber, Derby, Hyde, Barton, et al., 2009). Math racetrack intervention has been shown to be very effective in accuracy and fluency in math (Beveridge et al. 2006). With a math racetrack, the student orally answers math fact questions during a one-minute timing after they have been tutored (Beveridge et al., 2006). The facts are placed on the track in random order to avoid the student memorization of a pattern of answers. The student plots his correct and errors on a graph paper when the timing is completed. For some students consequences are provided if they improve from their previous timing (McLaughlin et al., 2009).

The purpose of this study was to increase the accuracy and fluency with basic multiplication facts for three elementary school students who were thought to be at risk for school failure in mathematics. Another purpose was to evaluate the efficacy of employing math racetrack and DI flashcards. A final purpose was to provide a replication of our previous research with math racetracks (Beveridge et al., 2006) with a different group of students (at risk elementary students), type of elementary school (rural vs. urban), and locate (Idaho vs. Washington State).

METHOD

Participants and Settings

There were three participants in this study. Student 1 was a 10-year-old male in the fourth grader enrolled in a regular education classroom. Student 2 was a 10-year-old female in the fourth grader that is in a regular education classroom. Student 3 was an 11-year-old male also enrolled in a general education classroom. None of the participants have been diagnosed with a learning disability, nor had Individual Education Plans (IEPs). All the students demonstrated deficits in accuracy and fluency for basic multiplication facts. The classroom teacher felt these three students would be great students for this study, after the first author conducted baseline observations, the first author concurred with the classroom teacher.

Student 1 was a 10–year-old male who is considered to be at- risk in mathematics by his teacher and other school staff. Currently, student 1 qualified for Title 1 assistance in reading, but did not qualify for any extra math assistance. According to his Idaho Standardized Achievement Test (ISAT) he was below grade level and working at the 3rd grade level in math. Finally he was very polite and eager to learn

Student 2 was a 10-year-old girl with behavior issues in the general education classroom, but had no formal diagnosis. At times, she would talk out loudly, walk around the classroom and bother other students. She had not mastered all of her basic multiplication facts and her teacher felt the one-on-one attention would be beneficial for her. According to Student 2’s teacher, her ISAT indicated she was at a late 3rd grade math level. At the beginning of the study the student was defiant, but after a few sessions the student became excited to learn her math facts. She also enjoyed the competitive aspect of the math racetrack.

Student 3 was a typical 11-year-old boy who had not mastered all of his basic multiplication math facts. According to his general education teacher, student 3 is able to process information orally but struggles when writing. She also felt the one- on-one attention would be beneficial for him to learn his multiplication facts. He did not qualify for any additional help in math, but did receive Title 1 for additional reading help three times per week. Student 3’s ISAT scores indicated that he was at the high 3rd grade level in math. He was very polite and eager to learn his math facts.

The study was conducted at an elementary school in rural Idaho. The school had an enrollment of approximately 193 students. Of those, 68% of the students qualified for the free or reduced lunch program. Two different locations in the school, the regular education classroom during recess or before school and the library were used. The preferred setting was the library because it was quiet and had fewer items to possibly distract the students. However, the library was a small room that was also used by the librarian for interacting with students looking for books to check out and the teaching of library skills. The study took place over 12 weeks on various days of the week. The general education classroom teacher did not want the students falling behind on classroom assignments so the times when data were gathered varied. For example if during their regular math class they required the whole period, the first author worked during the students during recess. The first author worked independently with each student. She worked with the students on a rotating basis after the inclass math period or at recess.

Materials

Flash cards for all multiplication facts from 0-10 (three sets), three math racetrack worksheets (see Figure 1), assessment sheets, a timer and observation sheets. These designed by the first author to record the results. The study also included 100 Basic Multiplication Fact Test worksheets; these worksheets were used for the pre-test and post- test. These tests were a standard version with all 100-math facts by operation. Additional worksheets were modeled after the standard version, but only consisted of the facts being targeted and previously mastered facts for each student. These tests were printed from the website, "mathdrills.com". This website has numerous tests available depending on the targeted facts. The materials used for participation rewards were a package of 12 pencils, pencil pouch, eraser and numerous pieces of candy for each student. The first author chose this reward after consulting with the classroom teacher.

Dependent Variables and Measurement

Number corrects and errors

The first dependent variable was the number of correct and error math facts. The target basic multiplication facts were determined from the pre-test and from the suggestions of the classroom teacher. These facts were divided into three sets of six facts per set. For Student 1, his sets included 4's for Set 1, 7's for Set 2 and 8's for Set 3. With Student 2, her sets included 6's for Set 1, 7's for Set 2 and 8's for Set 3. Student 3 sets included 4's for Set 1, 7's for Set 2 and 9's for Set 3. These sets and facts were reviewed and approved by the classroom teacher. If the students response was given correctly, for example the card reads 2 X 3= 6 and the student responds with 2 X 3 = 6, a + was placed on the data sheet. If, an error was found or the problem was not completed during the two-minute time allotment, then a minus (-) was recorded on the data sheet.

Number of correct digits per minute

The second dependent variable was the number of correct digits on a one-minute timed test. These data were gathered from three sets of math facts. For example, with the problems 3 X 6 = 18 and 5 X 8 = 40, 18 and 40 were counted as two digits correct with for a total of four digits correct. Examples of error digits included, 3 X 6= 16 and 5 X 8 = 45. In this example each product was counted as one digit correct and one digit in error. The timed test was administered at the end of each session following DI flashcard practice.

Correct math problems pre and posttest

This measure was the number of correct problems from each student's pre- and posttest. These tests were administered at the beginning of data collection and at the end in May.

Experimental Design and Conditions

A single subject multiple baseline (Kazdin, 2010) across three sets of targeted basic multiplication facts was employed. This was used to evaluate the effects of the Direct Instruction flashcard system and math racetracks.

Baseline

These sessions began by checking for basic multiplication fact mastery by presenting the 18 flashcards and the first author recording the responses. No feedback was given during this time. Baseline data on all sets consisted of the flashcard assessment of the 18 target facts. The number of baseline sessions ranged from 3 to 18 sessions for each student. These data were gathered from student pretest scores and from the suggestions of the classroom teacher as to which facts needed additional instruction. The number of sessions in baseline ranged from 5 to 23 sessions.

Direct Instruction flashcards and math racetrack

During this condition the Direct Instruction flashcard system and math racetrack procedures were implemented. The first author presented the 15 flashcards, 9 of the cards were previously mastered facts and 6 are the targeted facts. These sessions lasted approximately 10 minutes. The first author showed the student the flashcard and the student was to say the entire statement (e.g. 4 X 3=12), and not just the answer. If the student responded correctly within the 2 second allotted time, the first author placed the card in the back of the pile and presents the next fact. If the student correctly responded but took longer than 2 seconds, then the first author placed the card back two or three cards from the front of pile. If the student responded incorrectly, this same procedure is followed after the first author told the participant the correct answer, using a model, lead and test procedure (Marchand-Martella et al., 2004; Peterson, McLaughlin, Weber, Derby, & Anderson, 2008). The error card was again placed two or three cards back to provide intense review.

The second component of the intervention package to improve mastery was a math racetrack. A math racetrack was a game board like track that simulates a racetrack. A math racetrack contains 28 spaces on which to write math facts. The first author filled twelve of the spaces were filled with six target facts (twice each) and the other sixteen spaces were filled with previously mastered multiplication facts. At the beginning of each turn, the first author had the student use a pencil to follow and point at each square as they go. The first author prompted the student "on your mark, get set, go!" The students' were required to read the problem and state the answer as quickly as possible before they were allowed to move to the next square containing the next fact. The first author provided praise and feedback as the student tried to complete the track as fast as possible.

The first author also timed the track sequence and recorded each of the student's outcomes on a data worksheet. An example of the correct response was the student starting at the starting point, listening for the prompt, and the beginning the sequence of facts. The student read the first fact, for example 3 X 2=6 and then proceeded to the next box. If the student responded with an incorrect answer such as 3 X 5=12, then the first author stated 3X 5=15 and prompted the student to try again before advancing to the next box. The first author periodically gave feedback and praise during the session, which typically lasted 5-10 minutes.

All the session typically ended by the first author giving positive feedback to each student about the progress made that day. The first author also displayed excitement when the student showed improvement by completing the track in "record time," a time faster than the previous day's. The first author shared the student's daily progress with the classroom teacher.

Reliability of Measurement and Fidelity of the Implementation of the Independent Variables

Reliability for each of the measures was gathered. For each measure an independent but simultaneous measure was taken. When the students wrote the answers to their problems, the first author mask her grading and recorded the number of problems, or digits correct or in error. Point-by-point agreement scores were computed using the number of agreements by the number of agreements plus disagreements and multiplying by 100. Reliability data were taken each session. An agreement was scored if each observer scored each digit in the same manner. Any deviation in scoring was defined as a disagreement. Agreement for these measures was 100%.

Measures as to the implementation of the various experimental conditions (baseline or DI flashcards and math racetracks) were gathered on four separate occasions. The second author observed the first author and wrote down which condition was in effect and whether this condition matched definition of each. Agreement as to the accuracy of implementation of these two conditions was 100%.

RESULTS

The results for Student 1 are displayed in Figure 2. For Set 1 in baseline, Student 1 made no correct responses (M = 0.0). When DI flashcards and math racetracks were employed, the number correct problems increased (M = 5.32; range 0 to 6 problems) and his errors decreased (M = 1.68; range 0 to 7). During the baseline for Set 2, the average number of correct problems was low 1.56 (range 0 to 3). An increase in corrects was found when DI flashcards and the math racetrack were in effect (M = 4.33; range 1 to 6 problems), and a decrease for errors (M = 2.67; range 1 to 6). During baseline for Set 3, student performance remained low (M = 1.39; range 0 to 3). When DI flashcards and the math racetrack were implemented for Set 3, the mean number of correct problems increased (M = 4.33; range 2 to 6) and his errors declined (M = 2.67; range 1 to 5).

The outcomes for Student 2 are displayed in Figure 3. For baseline, which lasted five sessions, student 2's correct problems were low (*M* = 1.8; range 1 to 2) and her errors were high (*M* = 5.2; range 5 to 6 errors). When DI flashcards and the math racetrack were employed in Set 1, her mean problems correct increased to 3.81 with a range of 2 to 5. Her errors decreased (*M* = 3,29; range 2 to 5 errors). This student had difficulty with Set 2 and did not reach mastery until almost the end of data collection. For Set 3, her baseline correct facts were low (*M* = 1.28; range 0 to 3). The DI flashcard intervention and math racetrack was in effect for only two sessions. However, it did generate an increase in her performance over that in baseline for corrects (*M* = 3.0; range 2 to 4) and reduced her errors (*M* = 4.0; range 3 to 5 errors).

The outcomes for Student 3 are presented in Figure 4. During baseline for Set 1, the mean correct was 4.67 (range 4 to 6) and errors averaged 2.33 for errors. There was an increase in performance when DI flashcards and the math racetrack were employed with Set 1 (*M* = 5.81; range 5 to 6). In addition his errors decreased (*M* = 1.28; range 1 to 2). With Set 2, baseline performance was also low, (*M* = 2.6; range 1 to 4) with his errors being high (*M* = 4.4; range 3 to 6). An increase in problems correct was found when DI flashcards and the math racetrack were employed (*M* = 5.0; range 2 to 6), and a decrease in errors (M = 2.0; range 1 to 5). Baseline performance for Set 3 for was low (*M* = .18; range 0 to 1) and intervention lasted 15 sessions. However his correct problems increased to a mean of 5.27 (range 3 to 6).

Figure 5 presents the pre and the posttest results for all three students. Student 1 scored 47 out of 100 in the 5-minute written pretest, after intervention on all 3 sets, he improved to 61 correct out of 100 in 5 minutes on the written posttest. Student 2 scored 39 out of 100 on the written pretest. After intervention on all 3 sets, Student 2 improved his accuracy to 63 out of 100 on the written post-test. Student 3 scored 40 out of 100 on the written pre-test. After math racetracks and DI flashcards, over all 3 Sets of problems, he scored 68 out of 100 in 5 minutes on the written posttest.

DISCUSSION

The results for fluency for each participant indicated an increase for number of digits answered correctly, written on multiplication fact sheets. This finding was replicated across all three participants.

The results of the Direct Instruction flashcard system and math racetrack procedures proved to be effective in improving accuracy and fluency of all the target basic multiplication fact Sets for all three of the students. The present findings provide additional support for the efficiency of DI flashcards procedure.

Based on the data from the pre-test, the students had shown to have some previous knowledge of many multiplication facts, but needed help with fluency and accuracy on a few facts. The written pre-test for all three students showed they had mastered 0, 1,2,3,5, and 10's. Student 2 and 3 had also mastered 4's. The target facts that were chosen for all the students were also reviewed and suggested by the classroom teacher. The first author determined after intervention, that student 3 had motivation issues when writing the facts.

Math racetrack was also shown to be effective with an increase of problems answered correctly after intervention. The racetrack ended up being the student favorite part of intervention. We made it a "game", using characters for the Disney movie "Cars" to keep score. The students competed against each other, trying to keep their "Car" in first place. We made it fun!

With the implementation of the study, the students showed excitement and enthusiasm about the individualized intervention procedures and the personnel attention they received. The procedure really seemed to improve their motivation, making a competition between them. At the beginning of the study, student 2 engaged in some defiant behavior, insisting she did not need to do this project, but after 2 sessions and the "race" began, she was excited to help me. The group was very easy to get along with and responded well to instruction. All three of the student's thrived on the one-on-one attention.

Counting strategies (e.g. touch math, finger counting, and fact charts) tend to be used by students with learning disabilities and students who are considered to be "at-risk" (Lerner, 1999; Skinner, Beatty, Turco, &Rasavage, 1989). During baseline and intervention the first author noticed the entire student's using their fingers to count, especially during the pre-test and probe sheets. Unfortunately, these strategies typically result in the student having a slow pace while solving math problems. Using fingers to count can also weaken the student's performance on mathematical problem solving and related tasks (Skinner et al., 1989; Skinner & Schlock, 1995).

Rote memorization of multiplication facts allows students to significantly increase their speed during assignments with less effort and more speed. In addition being able to automatically recall basic math facts to solve more complex math problems and be successful in the upper level grades.

Direct Instruction flashcard system and math racetrack was very practical, efficient and easy to implement. If the classroom teacher of the parents wanted to employ these procedures, it wouldn't take much time and it would be easy to do in the classroom or at home. The procedure could also be used as a game, as we did with the "Cars". The students in this study enjoyed the game and were eager to learn and move on.

The only problem the first author encountered was time; it was hard finding the time to pull the students out of class to do the study. The classroom teacher didn't want the students falling behind in their regular assignment and classroom discussion so the first author had to wait until they were finished with their classroom work. Sometimes, the only time the project could take place was at recess or before school and the students freely gave their time.

The DI flashcard system and math racetrack were very cost effective. The materials needed for math racetrack were photocopies of the track, which were copied at home or at the school. The "Cars" used for the data were cut out on the Circuit die cut machine, the first author owns. For the Direct Instruction flashcard system, all that was needed was 2 packages of 4X6 index cards at the cost of $4.00 for both, a pen to write the facts and the printed data sheets, also printed at home. The fluency probe sheets were created from "mathdrills.com" with the appropriate target facts selected. The first author printed the tests. The only other cost was the price of the small gift, given to the students upon completion of the project at a cost of approximately $3.00 for each student. The gift consisted of some pencils, erasers, racetracks, numerous practice quizzes, their favorite candy bar and encouragement to keep practicing.

The first author felt confident the students could continue this procedure on their own because during the study the students demonstrated they knew the process. Overall, the study proved to be effective and beneficial to the three participants involved.

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FIGURES

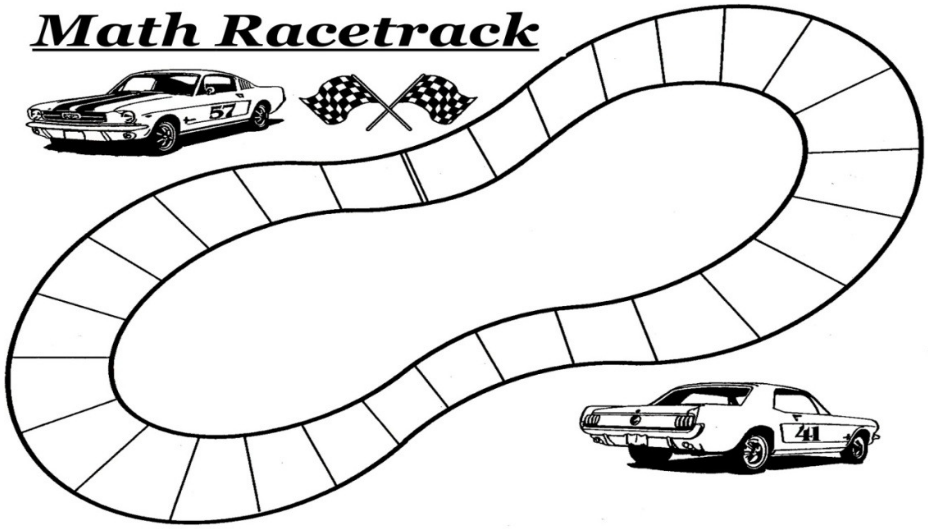

Figure 1.A sample math racetrack.

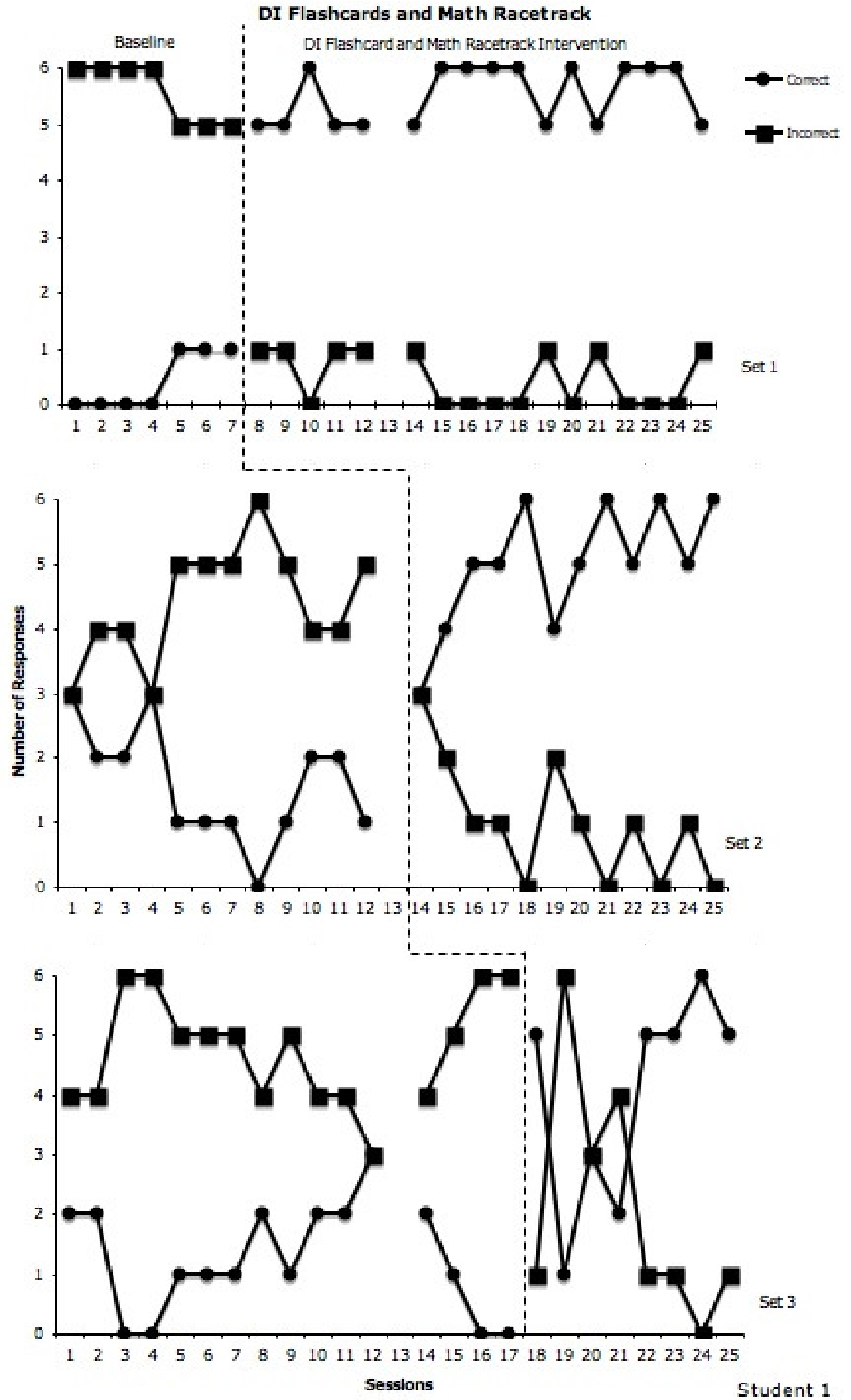
DI Flashcards and Math Racetrack
Baseline
DI Flashcard and Math Racetrack Intervention
Correct
Incorrect
Set 1
Set 2
Set 3
Number of Responses
Sessions
Student 1

Figure 2

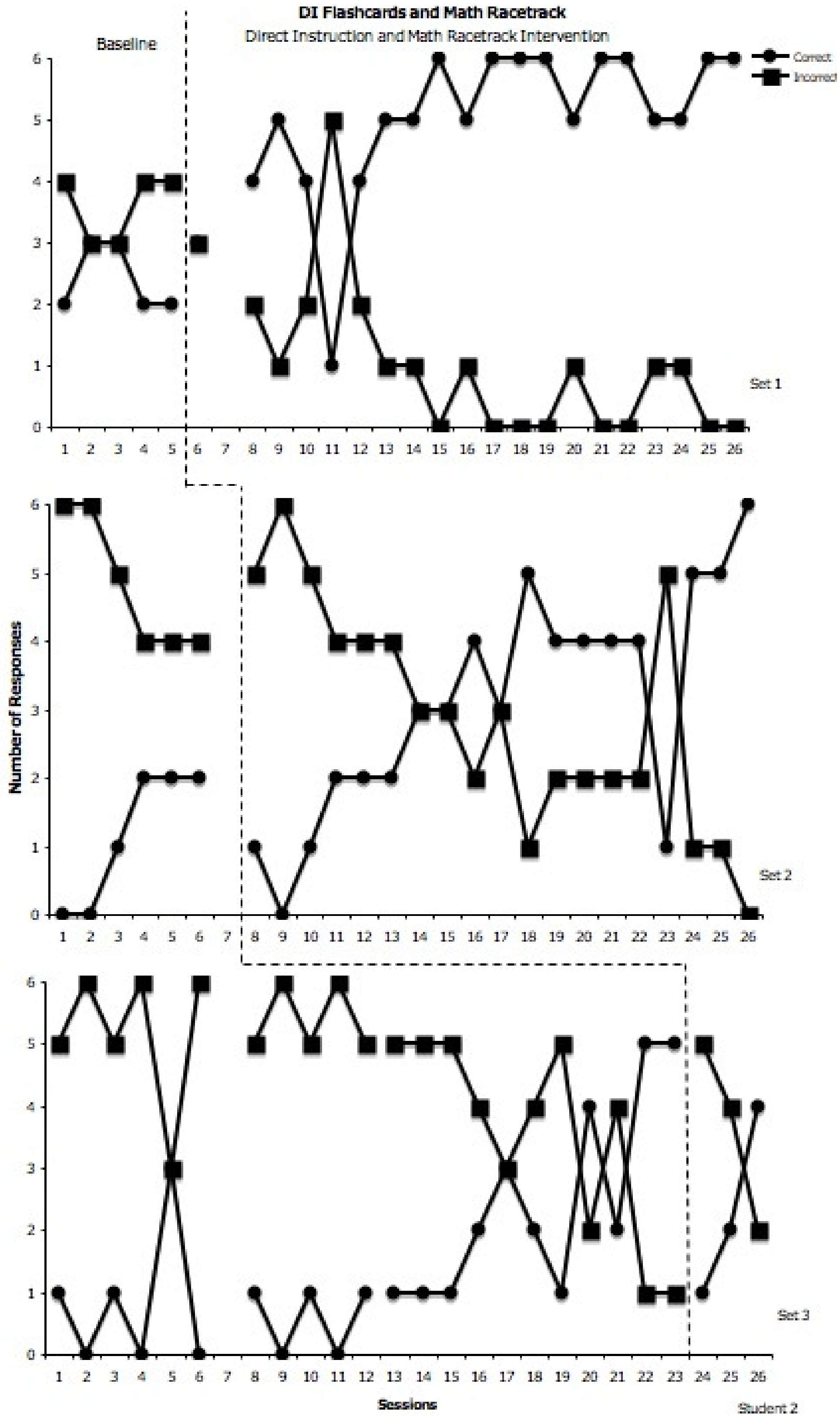
DI Flashcards and Math Racetrack
Baseline
Direct Instruction and Math Racetrack Intervention
Correct
Incorrect
Set 1
Set 2
Set 3
Number of Responses
Sessions
Student 2

Figure 3

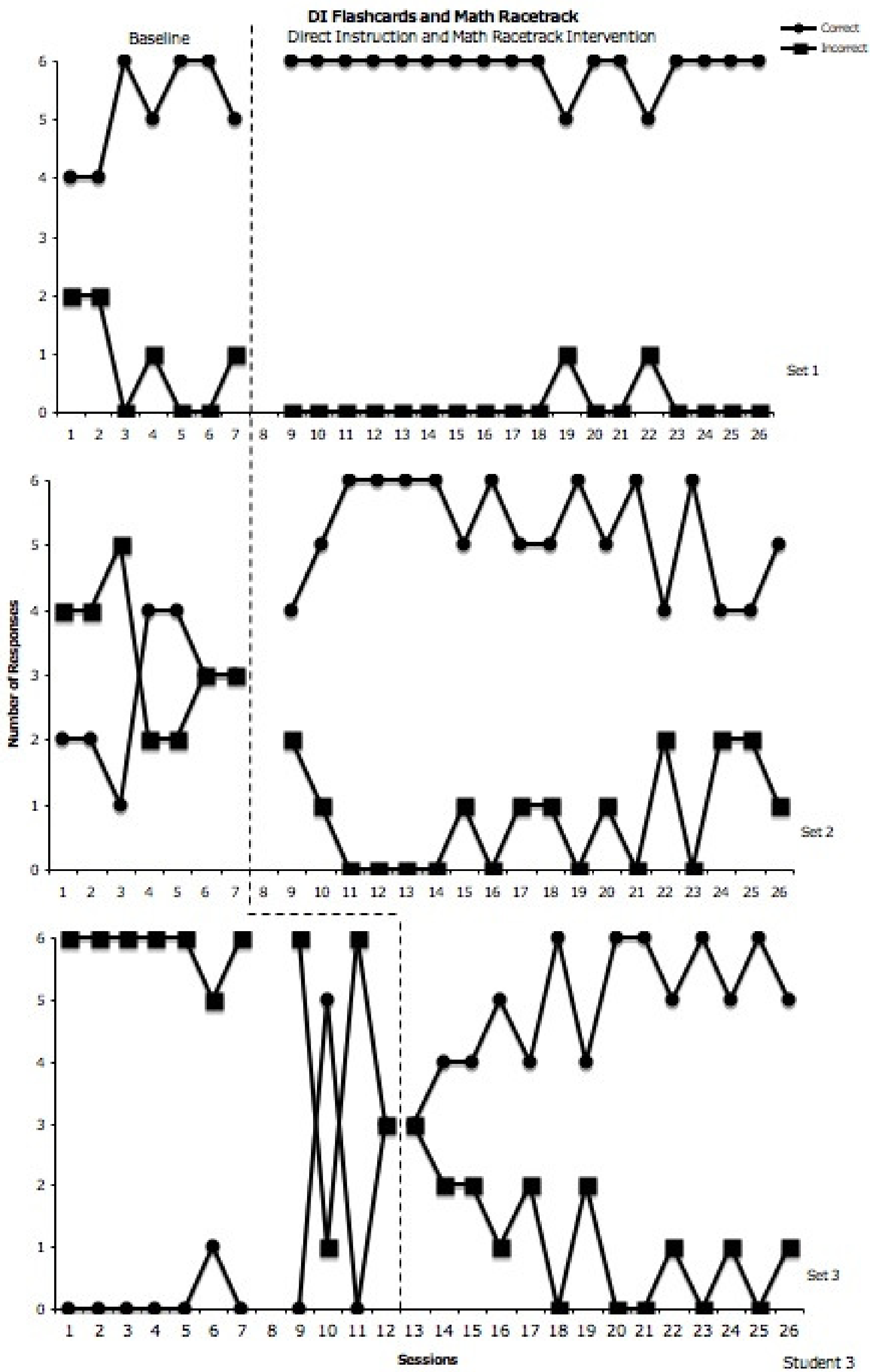
DI Flashcards and Math Racetrack
Baseline
Direct Instruction and Math Racetrack Intervention
Correct
Incorrect
Number of Responses
Set 1
Set 2
Set 3
Sessions
Student 3

Figure 4

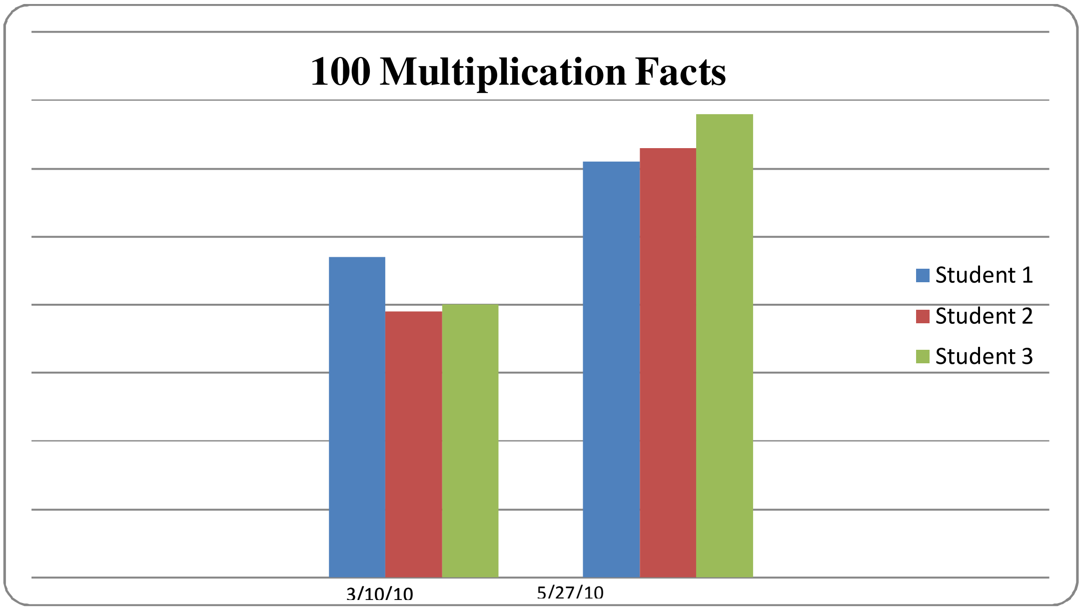

Figure 5.Pre and post test results for each participant