ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 3.4
IJAR 2015; 1(3): 66-77
www.allresearchjournal.com
Received: 19-01-2015
Accepted: 17-02-2015

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The effects of a direct instruction flashcard system to teach two students with disabilities multiplication facts

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Author Notes
This research was completed in fulfillment for the requirements of an Endorsement in Special Education in the Department of Special Education at Gonzaga University, Spokane, WA. The authors would like to thank the participant for allowing us to complete this study. Requests for reprints should be addressed to the authors, Department of Special Education, Gonzaga University, Spokane, WA 99258-0025 or via email at mharris3@zagmail.gonzaga.edu or jhelling@zagmail.gonzaga.edu

Abstract
The purpose of this study was to evaluate the effects of DI flashcard system mastery of the multiplication facts of a 12-year-old boy and a 15-year-old girl in their respective special education classrooms. Both participants were diagnosed with autism (ASD). When DI flashcards were employed performance for both participants increased. Larger gains were found for our elementary school participant. The DI flashcard procedure was easy to implement and evaluate. Suggestions for additional research with DI flashcards were made.

Keywords: Multiplication, autism, ASD, math facts, elementary student, secondary student, DI flashcards, multiple baseline design

1. Introduction
Students in secondary education with intellectual disabilities and autism are at risk to be further behind in a wide variety of subject areas including mathematics. Students who have not mastered their multiplication math facts have a higher risk of falling behind compared to their peers because multiplication facts are the basis for continuing onto higher levels of mathematics [1]. Without these it is difficult for students to advance or comprehend future mathematic classes. The term "intellectually disabled" is characterized by significant limitations both in intellectual functioning and adaptive behavior, which covers many everyday social and practical skills [2]. The disability is recognized before the age of 18 with an IQ score of 70 or lower. People with intellectual disabilities have much more difficulty learning new things, understanding concepts, solving problems, concentrating, and remembering than their typical developing peers. They usually need extra support or instruction to learn [2]. Students with intellectual disabilities may have a difficult time in social settings than their typically developing peers [3].
The term "autism" is characterized by a complex disorder of brain development, which is a result of a neurological disorder that has an effect on normal brain function affecting development of the person's communication and social interactions [4, 5]. Autism affects people in different ways depending on the severity of their disorder. "Expressive language level is probably the strongest predictor of outcome in the Autism Spectrum Disorder" [7]. This is used because expressions are a key factory in one's social skills considering a person should be able to identify how a person is reacting to a situation by their emotions. A person with autism may not notice that the person they are talking to is not interested in their story about what they ate for lunch. Some forms of autism can leave a person without speech and virtually no social skills. The main area that autism can affect people is in their social skills [4, 2]. They often lack the ability to generalize or interpret social cues from other individuals they are communicating with.

People with autism are found "to be of normal intelligence" which resulted in "people believing for many years the syndrome was psychogenic" [4]. While lacking the necessary social skills a child with autism typically struggles in a general classroom setting. They may loose interest and motivation in many subjects that are not appealing to them. Studies have shown that autistic children perform at a higher level in a smaller and more personal setting, which allows for the removal of distractions that are often prevalent in a general education classroom to help the students stay focused. While working one-on-one with a teacher the child can remain focused for longer periods of time.

Direct Instruction (DI) system has been used as an effective intervention for teachers to use in classrooms and it is show to improve students' mastery of math facts and allow students to maintain over time, [8, 9]. A study conducted by Brasch *et al.* [8] found an increase the rate of corrects and a decrease the rate of incorrect for math facts for two students enrolled in a special high school. Several recent studies across a large range of student populations including learning disabilities, intellectual disabilities, autism (ASD), developmental delays, behaviorally impaired, or clinical labels such as ODD/PD, etc). DI flashcards have been successfully implemented and evaluated in such classroom settings as preschool classrooms [10, 11] self-contained elementary classroom settings [12, 13], resource room classrooms [14, 15, 16], self-contained high school classrooms [8, 17]. DI flashcards have been shown to effectively increase mastery of basic skills. The procedure is cost effective for teachers to use and is easy to implement for all levels of instruction [14]. The DI flashcard system is a procedure that presents students with multiplication facts on flashcards. The system reinforces correct answers, while correcting the wrong ones. Repetition on the wrong answers is used to reinforce the correct ones and helping the students maintain the answers.

The purpose of the present research was to implement and evaluate DI flashcards in two classroom settings with two students with differing ages, classroom settings, and disability designations. The second purpose was to replicate the use of DI flashcards for improving math facts with two students with disabilities.

Method

Participants and Settings

Jennifer was a 15-year-old girl performing at about an 8th grade level. She attended public high school in a self-contained special education room. Jennifer was diagnosed with Intellectual Disabilities (ID) and had an IQ of 68 and a V.C. of 71. Her IEP stated; based on the Woodcock Johnson test that she was functionally delayed in writing, reading, and math. Her math score was 57 with fluency at 73, which is well below average. Her math goal was to verbally be able to do multiplication tables up to 10 with 100% accuracy in 5 sessions. The Wechsler Intelligence Scale for Children placed her at the IQ of 68. Her Perceptual reasoning was 84 and her working memory was 68. Math was her academic weakness. She was chosen because the teacher pointed out a need for her to memorize her multiplication math facts. In order to show significant improvement in her math knowledge and IEP goals, Jennifer would need to have her multiplication facts memorized.

Billy was a sixth grade, 12-year-old boy that had been diagnosed with autism (ASD). He was chosen because the Special Education teacher indicated he had difficulties in learning is basic multiplication facts. Billy was significantly behind from his peers in math. He was in a general education classroom where his general education teacher also saw a need for him to learn his multiplication facts. While all the other students were able to calculate the facts quickly, it often took Billy more time or he was had to use a calculator.

Jennifer's self-contained classroom was a public high school in the Pacific Northwest. It was a special education classroom with one certified teacher, three full time assistants, and two or three student volunteers. Jennifer and the other students went to adaptive P.E. and horticulture with the general education student each day. There was a wide range of disabilities in the classroom. They ranged from students who were physically incapable of eating and moving without assistance to those being integrated in general education classes for part of the day. The study was conducted in the back of the classroom at a table away from the distraction of the rest of the class. Jennifer was sat across the table and the data collector sat across from her with the person performing baseline and intervention. The researchers met with Jennifer twice a week and each session took about 15 minutes.

The study for Billy took place in an elementary school located in a large urban school district in the Pacific Northwest. Billy was pulled out of his general education classroom when he received to his special education services. Data were collected either in the resource room or in the hallway at a table if there were several other children or teachers working in the resource room. Billy met twice a week and each session lasted around 15 minutes.

Materials

The multiplication facts were placed on flashcards to they were easy for the students to read. Three by five index cards were used. The multiplication facts were written in marker with the answer on the back. They were randomly placed in sets.

Dependent Variable

The participants were measured on how many multiplication facts were correct in each set. A correct answer was the participant stating the whole multiplication fact and the correct answer within three seconds. An incorrect answer was any answer stated in error or the participants took longer then three seconds to answer.

The measurement for data collection was event recording. A pretest was given before the study took place, to determine the facts that each participant already knew. The pretest was administered by using flashcard, the researches took all of the basic flashcards and noted which ones the participants were able to answer correctly and which ones they either did not know or answered wrong. Four sheets were made for the facts the student missed during the pretest see (Appendix A). Each set of facts had a corresponding color to the color the set was labeled. A correct was marked with a plus, and incorrect was marked with a minus. After all of the facts had been shown then the researchers would tally up the correct and incorrect for each set. This data would be transferred to a graph to show the progress of the students.

Design

A single-subject multiple baseline design [18, 19] was used to evaluate the effects of Direct Instruction flashcard procedure

on the accuracy of math facts by Jennifer and Billy. Baseline for set one continued until there was a consistent trend showing the student's knowledge of the facts. Once, there was consistency Jennifer and Billy would be moved to intervention set 1. Set 1 intervention would continue until the participant could show 90% accuracy on the set of multiplication facts. For set 1 for Jennifer there were 4 session of baseline and intervention lasted 10 sessions. For Set 2 there were 8 sessions of baseline and intervention lasted 8 sessions. For Set 3 there were 11 sessions of baseline and intervention lasted 4 sessions. For Set 4 there were 14 sessions of baseline and intervention did not occur. For set 1 for Billy there were 3 sessions of baseline and 15 sessions of intervention. For set 2 there were 8 sessions of baseline and intervention lasted 10 sessions. For set 3 there were 13 sessions of baseline and intervention did not occur. The second set then began intervention. Billy and Jennifer moved on throughout the rest of the sets once the pervious set had been mastered with a trend of 90% accuracy.

Baseline

Before each time baseline was done, the participant was told to say the answer if they knew it or pass if they did not know the answer. The researcher presented the flashcards one at a time to the participant until all of the facts were given a response, the data recorders did not tell the participant if they were right or wrong. There was no prompting or consequences employed during baseline.

Direct Instruction Flashcards

During the DI flashcard intervention the participant was shown one card at a time and asked to give the correct answer. If they verbally responded with the correct answer the card was put on the table and verbal positive praise was presented. If the participant missed the multiplication fact, the administer said the multiplication fact and had the student repeat it. For example, the administer would say "6 X 6= 36" and then the participant would repeat "6 X 6= 36". That card was then moved three cards back for extra practice. The cards missed were only removed from the pile after the participant said it correctly three times more within three seconds.

Reliability of Measurement

The inter-observer agreement (IOA) was collected simultaneously but independently by two of the researchers. After the student completed all of the facts, the researchers then tallied up their results and compared their scoring. The computing method use was event ratio. IOA was collected during 33% of the sessions with 98% agreement (range 96 to 100%) for Participant 1. IOA was collected during 28% of the sessions with 99% agreement (range 93 to 100%) for Participant 2.

Results

Jennifer

The number of multiplication facts correct during baseline and intervention for participant 1 using the Direct Instruction Flashcard method is shown in Figure 1.

Set 1. As seen in Figure 1 in the first tier the mean percent of correct multiplication facts during baseline was 52% (range 50 to 58%). This was a stable trend so intervention in a multiple baseline design proceeded. The mean percent of correct multiplication facts during intervention was 88.3% (range 66-100%). Intervention was stable and increasing. The mean percent of correct multiplication facts increased from 52% to 83%.

Set 2. As seen in Figure 1 in the second tier the mean percent of correct multiplication facts during baseline was 45.5% (range 33 to 58%). For set 2 there was a stable trend of mastery so this led to intervention for set 2. The mean percent of correct multiplication facts during intervention was 85.3% (range 50 to 100%). Intervention was variable and increasing. The mean percent of correct multiplication facts increased to from 45.5% to 85.3%.

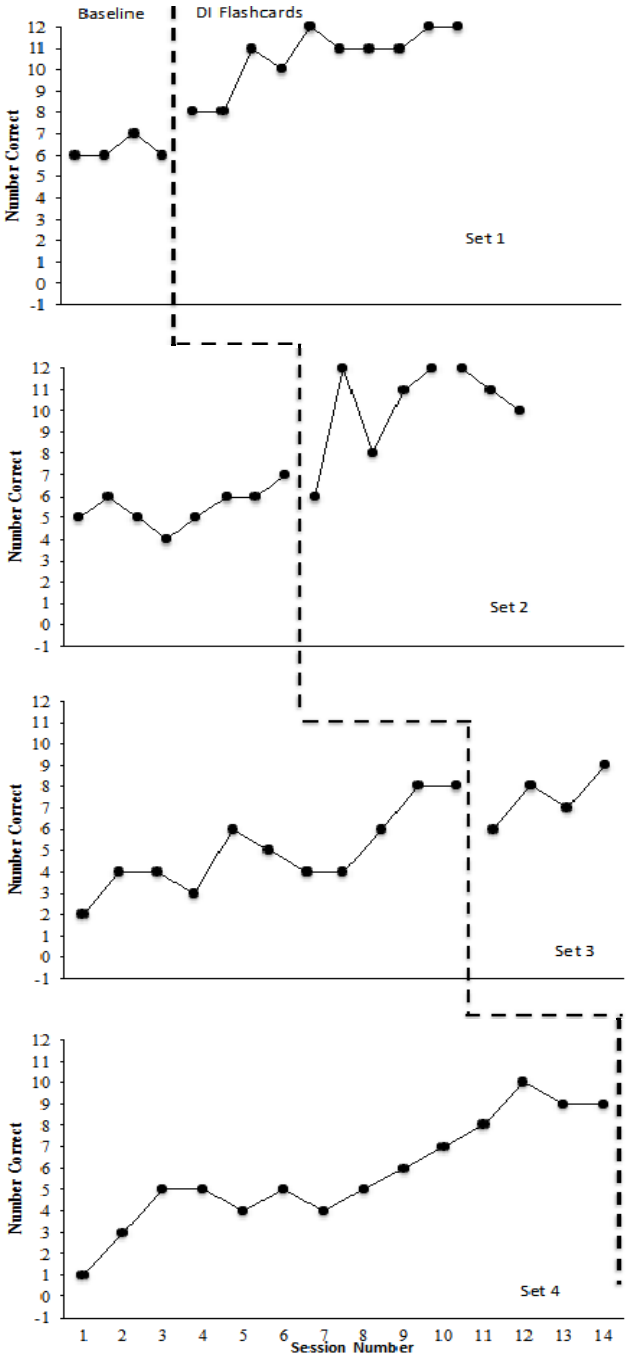

Fig 1: The number correct for Jennifer during baseline and DI flashcards across four sets of her math facts.

Set 3. As seen in Figure 1 in the third tier the mean percent of correct multiplication facts during baseline was 40.63% (range 17 to 66%).There was a stable trend of mastery for set 3 so intervention for set 3 occurred. The mean percent of

correct multiplication facts during intervention was 66% (range 58 to 75%). Intervention was variable and increasing. The mean percent of correct multiplication facts increased from 40.63% to 66%.

Set 4. As seen in Figure in the fourth tier the mean percent of correct multiplication facts during baseline was 47.85% (range 8 to 83%). Baseline was variable and increasing. There was an increasing trend in Set 4 and mastery was almost completed without intervention.

Mike

Set 1. As seen in Figure 2 tier one the mean percent of correct multiplication facts during baseline was 13.33% (range 0 to 20%). This was a stable trend so intervention for set 1 proceeded. The mean percent of correct multiplication facts during intervention was 92% (range 40 to 100%). Intervention for set 1 was stable and increasing.

Set 2. As seen in Figure 2 tier 2 the mean percent of multiplication facts during baseline was 2.5% math facts (range 0 to 20%). There was a steady trend so intervention for set 2 proceeded. The mean percent of multiplication facts during intervention was 58% (range 0 to 100%). Intervention was variable and increasing.

Set 3. As seen in Figure 1 tier 3 the mean percent of multiplication facts during baseline was 31% correct responses (range 20 to 80%). His baseline performance was variable with an increasing trend for accuracy

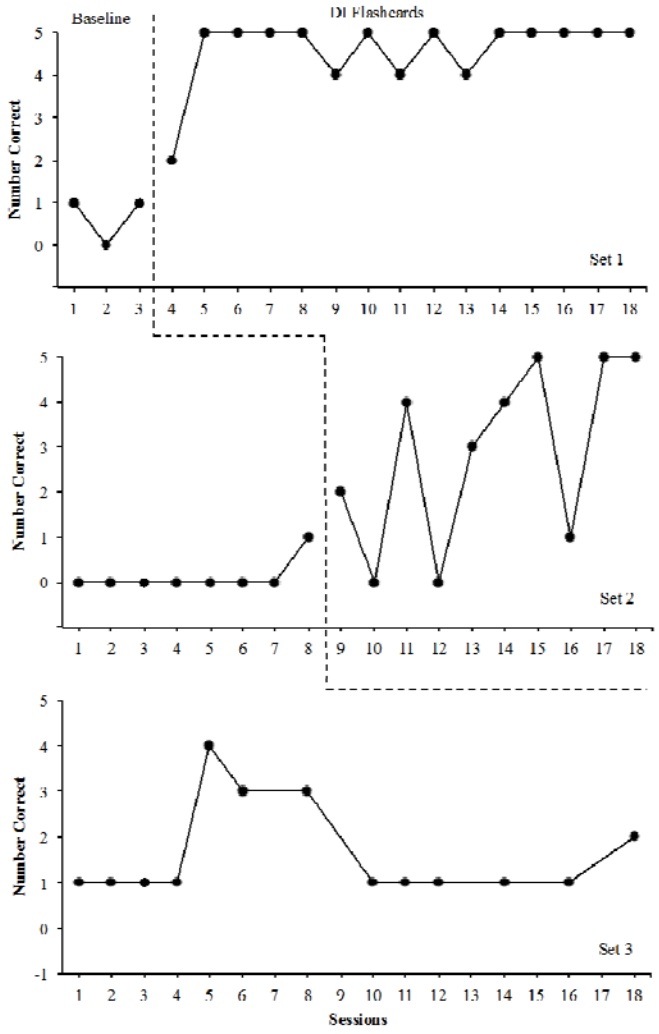

Fig 2: The number correct during baseline and DI flashcards for Mike.

Discussion

The DI flashcard procedure was effective for both participants. The multiplication facts that they consistently missed during baseline, their accuracy increased during DI flashcards were in effect. Direct instruction flashcard. The overall mean correct increased when compared to their baseline performance.

The strengths of the study were that the flashcards were easy to administer for intervention and baseline. The flashcards were very cost effective and required little work to create them. The method was easy for the participants to understand the procedures provided a consistent manner of teaching math throughout data collection. The students was able to determine how many flashcards were left in the pile and were motivated to decrease the size of their errors. Each student was motivated to work with the first three authors each day and enjoyed the one on one instruction. Teacher praise kept the participants excited and eager to learn their math facts.

The study had some weaknesses. First, spring breaks for both the first three authors and the participants fell close together that if left a large amount of time (two weeks) where data were not collected. Since the students had a large amount of multiplication flashcards to complete, this made the sets large and difficult to reach a criterion to move to the next set. Both students were unable to complete their last sets. The way the facts were arranged in groups could have been changed to leave the easier ones first and the more difficult in the later sets; instead of placing them all together. This can be seen in the outcomes for Mike. He failed to provide a steady trend of correct answers throughout the entire study. Also, he was not as consistent with his amount accuracy for Set 2 as he had been with Set 1. Implementing Set 2, actually confused Mike when he tried to remember the answers for each set. The adding of the new set clearly confused the participant. He often informed the second author was getting all the math facts mixed up. There was a minor effect on set one when the participant who consistently had got all the facts correct, would sometimes miss one or two during each test. He started to show a steady trend of getting the majority of problems correct in Set 1. With Set 2, he showed a variable trend in his performance and failed to learn all the facts. Finally, DI flashcards require one to one instruction. Teaching instructional assistants or employing fellow students in this process could do much to reduce the need for having one adult teach one student. Employing small group instruction [13] using DI flashcards has been suggested as a possible way to correct this issue.

The future direction of this project for Participant 1 would be to continue to work on the sets and make sure the facts were maintained in her memory. Multiple baseline and intervention sessions during each visit to allow more learning time would be another step to take. For future projects the arrangement of the facts would be changed to allow the student to gain the easier facts and build upon those as the sets increased.

Another direction that could have been taken with Participant 2 would have been to easily bring in section two maybe a problem at a time instead of whole sections. It was only when an entire section was added to have him remember, when the participant got the answers jumbled up and incorrect. If a new problem was added every time or every

other time then there would have been better results and a more consistent trend. All of the new problems that he was forced to remember at one hurt his memorization and ultimately lead to a wide range of results.

Overall for Participant 1 the student was motivated and the intervention worked well for the setting and the time allowed. The teacher was very happy with how the student was performing and the way participant was progressing. Continued support and positive feedback to keep motivational levels up and all the facts would be memorized quickly. Participant 2 had similar results by showing improvement on each of the sets tested. The teacher commented on how he was showing improvement on his multiplication skills in class as well. If this study had been continued the participant would continue to memorize more math facts, until he would be able to master the whole table.

The generalization of treatment effects [20, 21] to the untreated sets is of interest. What factors caused this for both of our participants remains somewhat unclear. However, the problem types in Sets 1 and 2 may well have caused this generalization to new untrained math facts. This issue will have to be assessed in further research. This is especially true as generalization remains a very important aspect of behavioral research [18, 21].

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