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THE DIFFERENTIAL EFECTS OF HAND-RAISING AND DIGITAL RESPONSE CARDS ON ACTIVE ENGAGEMENT OF HIGH SCHOOL STUDENTS WITH MILD TO MODERATE DISABILITIES DURING LITERACY ACTIVITIES

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in Education in the
College of Education
at the University of Kentucky

By

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ABSTRACT OF THESIS

THE DIFFERENTIAL EFECTS OF HAND-RAISING AND DIGITAL RESPONSE CARDS ON ACTIVE ENGAGEMENT OF HIGH SCHOOL STUDENTS WITH MILD TO MODERATE DISABILITIES DURING LITERACY ACTIVITIES

The purpose of the study was to investigate how both hand-raising and digital response cards effect student engagement, on-task behavior, and off-task behavior. Academic achievement was also assessed using a high-tech student responses system. An ABAB withdrawal design was used to evaluate the effects among high school students with mild to moderate disabilities during reading lessons. The results showed digital response cards increased active engagement for all participants, but digital response card conditions did not show increased levels of on-task behavior.

KEYWORDS: Mild to moderate disabilities, digital response cards, active engagement, student response systems, high school

Meredith Davis

May 4th, 2020

THE DIFFERENTIAL EFECTS OF HAND-RAISING AND DIGITAL RESPONSE CARDS ON ACTIVE ENGAGEMENT OF HIGH SCHOOL STUDENTS WITH MILD TO MODERATE DISABILITIES DURING LITERACY ACTIVITIES

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Overview of Alternative Thesis Project

During the Spring 2020 semester, students within the Teacher Leader Special Education Master's program were conducting applied thesis projects within typical contexts as part of their fulfillment of the requirements of a master's degree program. Due to the coronavirus disease (COVID-19), public schools and related facilities closed with no plans to reopen within the time frame to allow for graduation for students in the last semester of their graduate program. Students were allowed to complete an alternative thesis assignment in various forms. The following written prompt was assigned as an alternative to conducting an applied thesis project:

Alternate Thesis Project

Spring 2020

You will be given the written methods and results (including graphs) from a study conducted by Dr. Channon Horn and Elena Hitch in a public school classroom during the 2019-2020 academic year. Your task is to develop the introduction, review the methods, analyze the results, develop results tables, and write the discussion for the study. This should take the form of a paper that could be submitted as a research paper to a peer-reviewed journal in both length and tone.

Section 1: Introduction

Teachers need the most effective and efficient ways to teach their students. One method teachers use, that has been supported by researchers to facilitate learning, is to provide active engagement opportunities. Active engagement involves students contributing to lessons by performing a skill, answering a question, or responding to a task direction (Ault & Horn, 2018). Active engagement is in contrast to more passive instructional methods such as whole group lectures and individual questions and response (Schnorr, Freeman-Green, & Test, 2016). These passive methods result in decreased active engagement because students are not expected to respond, or they provide response opportunities for a limited number of students.

Because students with disabilities often do not display the same levels of engagement as their typically-developing peers, the Council for Exceptional Children has identified active engagement as a high leverage practice for teachers to utilize in their classrooms (McLeskey, 2017). Active engagement involves increasing the numbers of opportunities to respond during instructional sessions. Increasing opportunities to respond has been shown to promote student engagement in addition to decreasing challenging behaviors among elementary, middle, and high school students with disabilities (Common, Lane, Cantwell, Brunsting, Oakes, Germer, & Bross, 2020). Among elementary students with developmental disabilities, active engagement levels were higher when participants were given an opportunity to respond every 15 s than when they were given an opportunity to respond once per minute (Bolt, Hansen, Caldarella, Young, Williams, & Wills, 2019).

One method that has been used to increase opportunities to respond and engage multiple students during a lesson is the use of response cards. Response cards are signs or cards that are typically held up by all students participating in the lesson to show the teacher their response to a question or direction (Ault & Horn, 2018). This provides the opportunity for all students to respond simultaneously during the instructional session. Additionally, the teacher receives immediate feedback on all students' performance allowing for in-the-moment instructional decisions based on the accuracy of the student responses (Sutherland, Alder, & Gunter, 2003).

Researchers have compared the use of response cards with traditional methods of active engagement, such as hand-raising. They have found that response cards can increase active engagement, increase on-task behavior, decrease off-task or problem behavior, and increase academic performance. For preschool students with attending difficulties, response cards resulted in higher levels of appropriate behavior than hand-raising during whole group activities (Godfrey, Grisham-Brown, Schuster, & Hemmeter, 2003). Response cards also show benefits over hand-raising among elementary students with moderate to severe disabilities (Berrong, Schuster, Morse, & Collins, 2007; Bondy & Tincani, 2018). During calendar lessons, response cards in the form of a laminated calendar board resulted in higher levels of active responding, higher levels of on-task behavior, and lower rates of inappropriate behavior for elementary students with moderate to severe disabilities (Berrong, Schuster, Morse, & Collins, 2007). Bondy and Tincani (2018) compared the use of preprinted picture response cards to hand-raising during calendar and math activities for elementary students with autism spectrum disorder and intellectual disabilities. They found increased active engagement levels and

correct responding in the response card condition (Bondy & Tincani, 2018). Studies comparing response cards and hand-raising among middle school students have found similar results (Cakiroglu, 2014; Didion, Toste, & Wehby, 2020; George, 2010; Horn, Schuster, & Collins, 2006). For example, Horn, Schuster, and Collins (2006) taught telling time to middle school students with moderate and severe disabilities. They found that response cards resulted in increased acquisition of the target skill, increased active responding, decreased levels of on-task behavior, and decreased levels of inappropriate behavior. The response cards used were laminated flip boards that resembled a digital clock. Response cards resulted in increased academic performance during social studies activities in a study done by George (2010) among middle school students with emotional and behavioral disorders. Response card conditions showed higher levels of correct academic responding than hand-raising conditions (George, 2010). Another study found that when compared to hand-raising, response cards resulted in increased opportunities to respond and increased correct academic responses for middle school students with mild disabilities during social studies lessons (Cakiroglu, 2014). The response cards had four laminated pictures printed on them, and the students circled the correct response to questions posed by the teacher with dry erase markers. Didion, Toste, and Wehby (2020) investigated the effects of response cards in the form of individual whiteboards. The response card condition resulted in higher levels of engagement than traditional hand-raising when teaching math skills to middle school students with emotional and behavioral disorders (Didion, Toste, & Wehby, 2020).

Response cards can be low tech or high tech. Some low-tech examples of student response systems include printed pictures or words, whiteboards, yes/no paddles, and

students holding thumbs up or down. These are easy to implement, inexpensive, and increase engagement, but can be harder to differentiate due to the limited methods of responding they allow (Ault & Horn, 2018). Teachers also have to manually record data when using low tech systems if they want to use the data to inform later instruction.

High tech digital response cards have been referred to as digital response cards (DRCs) or student response systems. These response systems require an electronic device to use them such as iPads, Chromebooks, smart phones, and SmartBoards. The response systems also use the technology to gather and store student responding data by gathering responses students make on their individual devices or allowing teachers to scan student responses using one device. This information is delivered to the teacher. With increased technology in classrooms today, digital response cards, or systems that allow for responding and recording of student responses using an electronic device, are now an engaging option for active student engagement and assessment of learning (Ault & Horn, 2018). Assisting with the use of high-tech response systems is the trend that many schools now have to provide one-to-one technology programs. This means that each student has a device to use such as iPads and Chromebook computers, making it easier for all students to have access to a digital version of response cards. Some popular high-tech student response systems to poll and assess student responses are Kahoot (www.kahoot.com), Nearpod (www.nearpod.com), Poll Everywhere (www.polleverywhere.com), Socrative (www.socrative.com), and Plickers (www.plickers.com).

While most of these systems require that each student has their own device, Plickers is a student response system in which only the teacher needs to have a device.

The students respond by holding up a paper bar code that corresponds with their response (Kent, 2019). The teacher scans the bar code using a tablet or smartphone and responses are tracked into a report of student responses. Students are each assigned their own unique bar codes that act like DRCs. Student responses are also displayed in real time on the teacher's device, allowing for in-the-moment decisions to be made based on assessment of student responses.

Although low tech response cards have been compared to traditional hand-raising instruction with positive outcomes, there is a need for additional research on the differential effects of DRCs and what is traditionally done in classrooms to indicate active engagement, such as hand-raising (HR). The current study investigated how using DRC or HR affected active engagement, on-task behaviors, and off-task behaviors of students with disabilities during reading lessons. Pre- and post-test data of reading comprehension also were assessed using the Plickers application.

Section 2: Research Question

The following research questions guided the investigation:

1. What are the differential effects of a DRC condition versus a HR condition on the level of active engagement for high school students with low incidence disabilities during literacy activities?
2. What are the differential effects of a DRC condition versus a HR condition on the level of on-task behavior for high school students with low incidence disabilities during literacy activities?

Section 3: Method

Participants

The investigation included students with low incidence disabilities enrolled in a rural public high school in a southeastern state in the United States. A total of nine students (5 males and 4 females) ranging in age from 16 years 4 months to 20 years 1 month participated in the study. Seven of the students were Caucasian, one was African-American, and one was Asian. The students had previously documented IQ scores from the Weschler Intelligence Scale for Children (2014) between the range of 48 – 60 and each had a current individualized education program (IEP). All students participated in their state's alternate assessment. Salmon (pseudonym) was a male student, aged 16 years 11 months, who was identified with a mild intellectual disability. He was below grade level across all academic areas and had vocational, reading, written expression, and math objectives on his IEP. Skylar was a female student, aged 16 years 3-months who was identified as having autism spectrum disorder and attention deficit disorder. She had functional reading, writing, math, and daily living goals on her IEP. Skylar also had a behavior intervention plan (BIP) for decreasing the occurrence of self-injurious behavior and received occupational therapy to increase her fine motor abilities. Caleb was a male student, aged 16 years 6 months who was identified with a mild mental intellectual disability and osteogenesis imperfecta. He was below grade level across all academic areas, and had reading, written expression, math, and vocational goals. Caleb received physical and occupational therapy for gross and fine motor abilities. Maverick was a male student, aged 17 years 3 months who was identified as having autism spectrum disorder and attention deficit disorder. Maverick had functional vocational, reading,

written expression, and math objectives on his IEP. Additionally, he received speech therapy once a week for expressive language skills. Maverick also had a BIP to increase on-task behavior and task completion. Jonah was a16-year-old male student who was identified with other health impairment. He had a mild intellectual disability, a seizure disorder and attention deficit disorder. Jonah had reading, written expression, and functional math goals on his IEP. He also had a BIP to reduce the occurrence of talk outs during instructional activities. Susan was a female student, aged 16 years 7 months who was identified as having a mild intellectual disability. Her IEP contained goals for reading, math, and written expression skills. Susan received speech therapy for receptive language skills. Body was a male student, aged 20 years 1 month diagnosed with a moderate intellectual disability and Down syndrome. Body's IEP contained functional academic skills in the area of reading and math. Body received physical therapy to increase gross motor capabilities. Elenore was a female student, aged 19 years 2 months, with a mild intellectual disability who was also an English Language Learner. She had objectives related to reading, written expression, math, and vocational training skills. Tatum was a female student, aged 18 years 4-month old with a mild intellectual disability and a Down syndrome diagnosis. Tatum's IEP contained functional academic goals associated with reading, math, and vocational training. All students received services in the resource classroom for students with disabilities for at least 70% of the school day.

The participants' special education teacher conducted all sessions. She had a Master's degree in special education, a teaching license in moderate to severe disabilities (K-12), and 21 years teaching experience. Although two paraeducators were present

during the study, they were assigned administrative type tasks to complete during the study sessions and were not actively engaged with students.

The primary data collector was a researcher with a Ph.D. in special education. The reliability data collector was a student obtaining a Master's degree in Applied Behavior Analysis.

Instructional Setting and Arrangement

The setting was a rural public high school in the moderate to severe disabilities resource classroom. Sessions occurred during a time that the teacher was typically teaching language arts. Along with the nine participants, the teacher, and the paraprofessionals, there were three peer tutors in the room during the language arts sessions. Participants were seated at two large group tables facing the teacher and a Smartboard.

Materials/Equipment

The teacher downloaded passages from Don Johnston's Start to Finish Online Accessible Library (Don Johnston Human Learning Tools, 2020). The Don Johnston Start to Finish reading program is a commercially available product that adapts high school literature to an elementary reading level. The literature is professionally narrated, utilizing age appropriate language and offers word highlighting while the passage is visually displayed on the Smartboard. The teacher provided each student with a 21.59 x 27.94 cm black and white photocopy of the page being displayed on the Smartboard and allocated 2 min for each student to position the page in their spiral bound notebook. The photo copy aligned directly with the information being displayed on the Smartboard. The

books (e.g., *Journey to the Center of the Earth* and *Percy Jackson: Lightning Thief)* used in the study were selected by the teacher. During all sessions, the participants had access to the page that was being read and materials to highlight or underline important information from the passage. During the intervention condition, the participants had access to an iPad. Students used the Doodle Buddy Whiteboard app which had been previously downloaded on each device (Pinger, Inc., 2010). Doodle Buddy is a free drawing app that allows users to select tools and colors to write on the iPad screen during the intervention condition. The participants also had been assigned a Plickers card (Amy, 2013). Plickers are individualized QR codes that allow educators to immediately collect multiple choice formative assessment data to teacher directed questions. The Plickers were copied on 21.59 x 27.94 cm pieces of cardstock and contained a black QR code. Plickers were used by all participants to respond during pre- and post-tests to measure academic achievement. The researcher collected academic responses from the QR codes by scanning the code displayed by each participant with the Plickers application downloaded on an iPhone. Data sheets were used by the observers for interobserver agreement of on-task and hand raising, and to measure procedural fidelity. MotivAiders® (www.habitchange.com) were used to signal observers as to the beginning and end of each scoring interval for on-task behavior.

General Procedures

Sessions were conducted one time a day, Monday through Thursday, during the 40-min language arts class that occurred at 12:20 in the afternoon within a whole class instructional arrangement. The study was conducted within the context of the ongoing classroom structure that was in place prior to the start of the study. The teacher

greeted students individually as they transitioned into the classroom from lunch and instructed students to gather their language arts materials and find their seat. Once all students had transitioned and were positioned in their assigned seat, the teacher provided an attentional cue similar to "Now let's get to reading." The teacher would then display the literature on the SmartBoard and each word was highlighted as the computer program read it to the group. The teacher paused the recording after every paragraph and asked comprehension questions to the whole class in which individual students would respond.

Data Collection

The three dependent variables during each condition were (a) active engagement, (b) on-task behavior, and (c) off-task behavior. Data were collected daily on on-task and active engagement behaviors. Academic achievement data were collected prior to and at the conclusion of instruction on each chapter.

Active engagement. Active engagement in the HR condition was defined as a student raising his/her hand at or above shoulder level within 5 s of the teacher asking the question. Active engagement in the DRC condition was defined as a student writing on the iPad and holding the iPad at or above shoulder level within 5 s of the teacher asking the question. The percent of active engagement for the entire group was calculated by totaling the number of students actively responding, dividing by the total number of students given an opportunity to respond, and multiplying by 100. To collect data on active engagement, for each question presented by the teacher, the observers scored the occurrence or nonoccurrence of responding (i.e., raising their hand in the hand raising condition or responding using the iPad in the DRC condition).

On-task and off-task behavior. On-task behavior was defined as students actively responding to the teacher's questions. This included the behaviors of raising their hand higher than shoulder level, verbally responding to a teacher question, writing a response on the iPad, and holding the iPad at least shoulder high after responding with the screen turned toward the teacher. Other on-task behaviors were looking at the teacher when she was speaking, looking at another student when they were speaking, looking at another student when they were responding, and talking to another student or another teacher/peer tutor about the content of the class. Off-task behavior was defined as students not attempting a response to the teacher's questions. This included the behaviors of failing to raise their hand, failing to verbally respond to a teacher question, doodling on the iPad, and engaging in any other application on the iPad other than Doodle Buddy. Other off-task behaviors were looking at any other individual while the teacher was speaking, being physically turned away from the speaker, engaging in off topic conversation with another student or another teacher/peer tutor during instructional sequences. To record on-task or off task behavior, researchers used a 60 s momentary time sampling data recording system (Cooper, Heron, & Heward, 2020). At the end of each 60 s interval, the researcher scored an occurrence or nonoccurrence of on-task behavior for all students by scanning from right to left beginning in the back of the classroom and moving forward. For each session, the number of occurrences of on-task intervals for the nine students was divided by the total number of intervals observed and multiplied by 100 to derive the percent of intervals of on-task behavior. To collect reliability for on-task behavior, the observers synchronized two MotivAider® devices

(www.habitchange.com) so that each signaled the end of 60 s intervals. The on-task behavior for all students was scored at the end of each interval.

Academic achievement. Academic achievement data during all experimental conditions were collected using the Plickers application during pre and post-tests for each chapter. Pre-tests were administered immediately prior to starting each chapter and post-tests were administered immediately following the conclusion of the chapter. Five questions (who, what, when, where, and why) were created by the reliability observer and approved by the primary data collector and the classroom teacher as being of equal difficulty for each chapter. The questions were presented one at a time on the SmartBoard with four multiple choice options. Each participant had a Plicker containing a QR code assigned to them and had been previously taught to display their desired response by positioning the Plicker card so their response option was displayed at the top of the Plicker and faced away from the student's body. The students would display their response at or above shoulder level facing the researcher. The researcher then used an iPhone with the Plickers application downloaded to scan the students' Plickers, capturing their answers.

Procedures

Hand-raise condition. Prior to the start of each session, the teacher reminded the students to answer questions by raising their hands, she did this through the use of a verbal prompt paired with physical model. During the Hand Raise (HR) condition a portion of a chapter from the selected book was read by the computer program while being displayed on the SmartBoard. The teacher would pause the computer program after each paragraph and ask a minimum of two or a maximum of three questions pertaining to

the material previously presented. Questions consisted of true/false, yes/no format, with one short answer question pertaining to the student's thoughts or feelings on the information presented. After the entire chapter had been read, the teacher reviewed the chapter and embedded a minimum of four and a maximum of five questions into her review. True/false, yes/no, or multiple-choice questions with four possible response options were asked. Data collectors recorded the occurrence or non-occurrence of each participant raising his or her hand within 5 s of the question being asked. Only one participant who raised a hand was called on by the teacher to answer the question. If the participant answered correctly, the teacher delivered descriptive verbal praise. If the participant answered incorrectly, the teacher called on another participant that also had his or her hand raised. Five sessions were conducted in each HR condition.

Digital response card condition. Similar to HR conditions, after the chapter was read the teacher reviewed the chapter and embedded questions into her review. Prior to the first question being asked, the teacher told the students they were using iPads to answer her questions and to write T/F, Y/N, or A, B, C, or D as a response. The data collector recorded active engagement following each question by recording the occurrence or non-occurrence of each student using his or her iPad to respond to the question within 5 s of the question being asked. The teacher then provided descriptive verbal praise for correct responses and corrective feedback for incorrect response to the whole group. Five intervention sessions were conducted in each condition.

Pre- and post-assessments. Pre and post assessment data on reading comprehension were collected prior to a book chapter beginning and immediately following the conclusion of a book chapter during all experimental conditions using the

Plickers application. Pre-tests were administered prior to starting each chapter and post-tests were administered immediately following the conclusion of the chapter. Five questions (who, what, when, where, and why) were created by the reliability observer and approved by the primary data collector and the classroom teacher as being of equal difficulty for each chapter. The questions were presented one at a time on the SmartBoard with four multiple choice options. Each participant had a Plicker card containing a QR code assigned to them and had been previously taught to display their desired response by positioning the Plicker card with their response option displayed at the top of the Plicker card and faced away from the student's body. The students would display their response at or above shoulder level facing the researcher. The researcher then used an iPhone with the Plickers application downloaded to scan the students' Plicker card, capturing their answers. The exact same pre-post assessment questions were presented during each chapter of the book, with each chapter having an individual set of questions. Two pre-post assessment measures were collected during each condition of the study.

Experimental Design

An ABAB withdrawal design (Gast, Ledford, & Severini, 2018) was used to analyze the effects of the HR and DRC conditions on the on-task, off-task, and active engagement behaviors as well as the academic achievement of all students in the class. The design was conducted based on the structure of the classroom. The first condition was the HR condition, which was the procedure that was normally used in the classroom. In this condition, the teacher presented literature to the whole class and then asked students to raise their hand to answer comprehension questions. In the DRC condition, each student had an iPad. The teacher asked comprehension questions and directed

students to use their iPad to respond and then show their response to her by holding it up with the screen in her direction. The implementor was the classroom teacher and the sessions took place during the students' regularly scheduled literacy block, promoting generalization and ecological validity. Experimental control is established when a change in behavior occurs only in the intervention conditions (digital response card conditions) and not in the baseline conditions (hand-raise conditions).

Reliability

Interobserver agreement data for on-task and student engagement behaviors were collected for 25% of the sessions and at least once in each condition. Interobserver agreement was gathered by having a second observer independently score on-task and active engagement behaviors. Two individuals served as reliability observers. The first was the reliability observer who was seeking a Master's degree in Applied Behavior Analysis and collected reliability data when the primary data collector was present. The second was a peer tutor in the classroom who collected reliability data when the first author was unavailable.

On-task and off-task behavior reliability. A point-by-point formula was used to calculate interobserver agreement in which the number of agreements was divided by the number of agreements plus disagreements and multiplied by 100 (Ledford & Gast, 2018). The overall mean interobserver agreement was 92% (range, 88%-100%).

Active engagement reliability. For each question asked, researchers scored responding for all students and point-by-point agreement was figured using the same point-by-point formula described in the on-task section. The overall mean interobserver agreement was 100%.

Procedural reliability data were collected during 30% of all sessions. During the first HR condition, procedural fidelity data were collected during 40% of sessions. During subsequent conditions it was collected 40% of the first DRC condition, 20% of the second HR condition, and 20% in the second DRC condition. For each condition, the researcher recorded the teacher's correct implementation of six procedural steps in each condition. The researcher scored the occurrence of the following teacher behaviors: materials prepared, attentional response provided to entire group describing the condition in effect, question provided, 5 s wait response time provided, individual student called on (HR condition) or cue provided for all students to respond (DRC condition), correct consequences provided, and a minimum number of questions asked. The number of questions asked could range from a minimum of 6 to a maximum of 17 depending on the number of paragraphs read and if the chapter concluded during the session. The number of teacher behaviors observed was divided by the number of teacher behaviors that were planned and multiplied by 100 (Billingsley, White, & Munson, 1980). All procedural reliability percentages were 100%.

Section 4: Results

Active Engagement

The overall percentages of active engagement are shown in Figure 1. The mean percent of active engagement across all participants during the first HR condition was 19.2% (range, 0%-90%). In the first DRC condition, the mean percent of active engagement across all participants was 82% (range, 40%-100%). The second HR condition had a mean percent of 17.6% (range, 0%-80%) for active engagement across all participants. In the second DRC condition, the mean percent of active engagement across

all participants was 99.4% (range, 90%-100%). The individual means for each student also were calculated and these data are included in Table 1. All students had higher means of active engagement in the DRC conditions than in the HR conditions. During the first HR condition, active engagement had a stable trend at low levels. When the first DRC condition was introduced, there was an immediate effect with a therapeutic increase in level. During the second HR condition, active engagement had an immediate return to baseline levels and stayed stable. For the final DRC condition, there was an immediate effect and active engagement stayed stable at near 100% levels. There was no overlap for active engagement between DRC and HR conditions. This shows a functional relation between DRCs and active engagement of the students because there are three basic demonstrations of effect in the mean percentage data with consistency of effect across conditions.

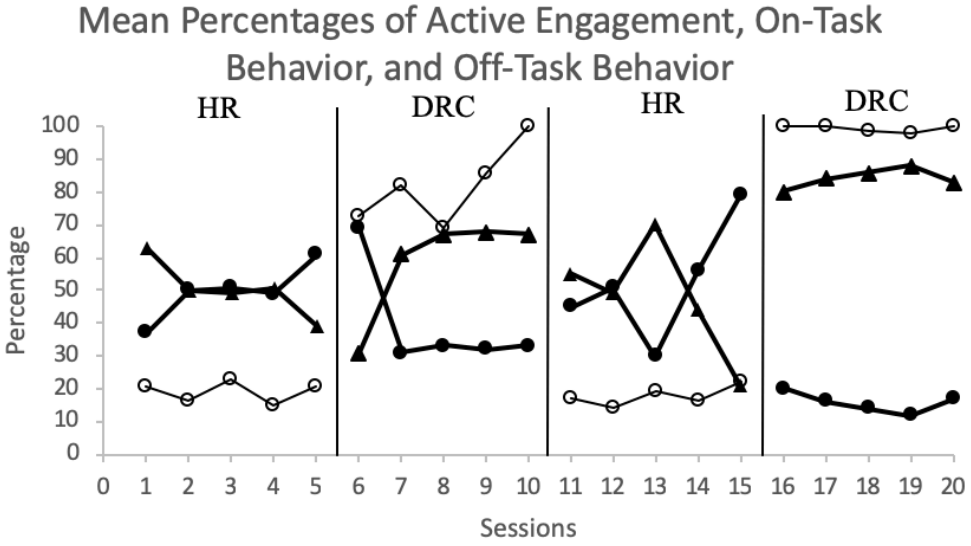

Figure 1. Open circles represent percentage of active engagement, closed triangles represent percentage of on-task behavior, and closed circles represent percentage of off-task behavior. Levels of active engagement are elevated in the DRC conditions.

Table 1

Mean Percentage of Active Engagement, Mean Percentage of On-Task Behavior, and Mean Percentage of Off-Task Behavior

Student	Condition			
	HR 1	DRC 1	HR 2	DRC 2
	Mean Percent of Active Engagement			
Salmon	10%	100%	10%	100%
Body	2.5%	84%	2%	100%
Susan	35%	90%	16%	97.5%
Tatum	10%	96%	10%	100%
Elenore	10%	82%	4%	100%
Caleb	46%	86%	44%	100%
Maverick	10%	90%	12%	98%
Jonah	72.5%	84%	68%	100%
Skylar	2%	90%	3.3%	100%
	Mean Percent of On-Task Behavior			
Salmon	40%	67.6%	49.5%	85.2%
Body	65%	33.8%	37%	81.6%
Susan	63.8%	68.8%	64%	88.3%
Tatum	59%	72.8%	60.6%	95.8%
Elenore	55%	65.4%	49.4%	95.6%
Caleb	53%	54%	49%	84%
Maverick	57%	68.2%	62%	91.2%
Jonah	51.3%	66.2%	46.6%	82.8%
Skylar	31%	33.4%	16.3%	63.2%
	Mean Percent of Off-Task Behavior			
Salmon	60%	32.4%	50.5%	14.8%
Body	35%	66.2%	63%	18.4%
Susan	36.3%	31.2%	38%	11.8%
Tatum	41%	27.2%	39.4%	4.2%
Elenore	45%	34.6%	50.6%	4.4%
Caleb	47%	46%	50.6%	16%
Maverick	43%	31.8%	38%	8.8%
Jonah	48.8%	33.8%	53.4%	17.2%
Skylar	69%	66.6%	83.7%	36.8%

On-Task and Off-Task Behavior

The overall average percentages of on-task behavior are shown in Figure 1. The mean percentage of on-task behavior across all participants for the first HR condition was 50.4% (range, 5%-90%). In the first DRC condition, the mean percentage of on-task behavior across all participants was 58.8% (range, 17%-100%). In the second HR condition, the mean percentage of on-task behavior across all participants was 47.8% (range, 0%-95%). The final DRC condition had a mean percentage of 84.2% (range, 50%-100%) for on-task behavior across all participants. The individual means for each student were calculated and are reported in Table 1. These individual data show slight differential effects for Salmon, Tatum, Elenore, and Jonah for on-task behavior in HR and DRC conditions. The overall means of on-task behavior also reveal slight differential effects. During the first HR condition, on-task behavior was variable but decreasing in level. During the first DRC condition, there was not an immediate effect, but the data did increase in level in in a therapeutic trend above baseline levels despite some overlap. When the HR condition was reintroduced, the levels of on-task behavior became variable again and had many overlapping data points with the first DRC condition. When the final DRC condition was introduced, there was an immediate effect and the levels of on-task behavior increased beyond baseline levels with no overlap. Due to the overlap of the first DRC condition and both HR conditions, it cannot be stated that there is a functional relation with these data.

The mean percentage of off-task behavior across participants for the first HR condition was 49.6% (range, 10%-90%). In the first DRC condition, the mean percentage of off-task behavior across all participants was 39.6% (range, 7%-83%). The mean percentage of off-task behavior across all participants for the second HR condition was 52.2% (range, 5%-100%). In the second DRC condition, the mean percentage of off-task behavior across all participants was 15.8% (range, 0%-53%). The overall average percentages of off-task behavior are shown in Figure 1. The individual means for each student were calculated and reported in Table 1. The overall means show lower levels of off-task behavior in DRC conditions than in HR conditions. The individual means show lower levels of off-task behavior in the DRC condition for Salmon, Susan, Tatum, Elenore, Maverick, Jonah, and Skylar. During the first HR condition, the data was variable and increasing in level. When the first DRC condition was introduced, the first data point showed an immediate increase in level, and then the data moved to a stable trend at levels below the first HR condition. There was one overlapping data point between these conditions. The second HR condition showed the levels of off-task behavior becoming more variable and overlapping with both the first HR and DRC conditions. The final DRC condition showed an immediate effect and the level moved below baseline in a stable trend. The final condition does show results in decreasing off-task behavior, but due to the overlap and variability of the data in the HR conditions and first DRC condition, a functional relation is not demonstrated.

Pre- and Post-Tests of Reading Comprehension

Individual means for all participants were calculated for both pre- and post-tests, and these data are reported in Table 2. Pre- and post-tests were conducted for each of

eight book chapters presented during the literacy activities. The mean percentage of pre-test scores across all participants was 30.3% (range, 0%-80%). The mean percentage or post-test scores across all participants was 53.5% (range, 0%-100%). Pre- and post-tests for Chapters 4, 5, 8, and 9 were done in the HR condition. The pre- and post-tests for Chapters 1, 6, 7, and 10, were done in the DRC condition. The average pre-test score for HR conditions across all students was 36.1% (range, 20%-80%). The average post-test score for HR conditions across all students was 43.8% (range, 0%-100%). For DRC conditions, the average pre-test score across all participants was 27.9% (range, 0%-80%) and the average post-test score across all participants was 54.7% (range = 0%-100%).

Individual average percentage increases from pre- to post-tests for both conditions are shown in Table 3. In summary, Salmon, Body, Susan, Tatum, Caleb, and Jonah showed more gains in DRC conditions between pre- and post-tests. These participants had higher percentage increases from pre- to post-tests when reading in the DRC condition. There were 16 pre- and post-tests in total. Salmon, Tatum, and Caleb participated in all pre- and post-tests. All other participants missed at least one pre- or post-test during the study. Body, Susan, and Skylar had data for 15 out of the 16 pre- and post-tests. Elenore, Maverick, and Jonah had data for 14 out of the 16 pre- and post-tests Overall, six students had greater percent increases from pre- to post-tests in the DRC condition, two students had greater percent increases from pre- to post-tests in the HR condition, and one student showed no difference between conditions. Most students demonstrated that the DRC conditions resulted in increased acquisition of the comprehension from pre- to post-tests.

Table 2

Mean Percentage of Skill Acquisition

Student	Pre-tests	Post-tests
Salmon	32.5%	65%
Body	30%	32.5%
Susan	32.5%	72.5%
Tatum	30%	60%
Elenore	22.5%	32.5%
Caleb	42.5%	65%
Maverick	30%	47.5%
Jonah	27.5 %	50%
Skylar	30%	40%

Table 3

Average Percentage increase from Pre- to Post-test

Student	HR Condition	DRC Condition
Salmon	30%	35%
Body	15%	26.7%
Susan	45%	53.3%
Tatum	20%	40%
Elenore	20%	20%
Caleb	25%	35%
Maverick	33.3%	13.3%
Jonah	13.3%	40%
Skylar	13.3%	10%

Section 5: Discussion and Limitations

Among nine students with mild to moderate disabilities, the researchers examined active engagement, on- and off-task behavior, and academic achievement when digital response cards were used during literacy activities. Based on the data that were recorded, several statements can be made. First, the DRC condition resulted in an increase in level of active engagement for all students, especially in in the second intervention condition. During HR conditions, levels of active engagement for the whole group averaged 18.4%, ranging from 0%-90%. During DRC conditions, levels of active engagement for the whole group averaged 90.7%, ranging 40%-100%. All participants with the exception of Jonah showed three basic demonstrations of effect. These results indicate a functional relation between DRC and active engagement. Second, both DRC conditions resulted in higher levels of on-task behavior for Salmon and Jonah. Both students' data showed 80% nonoverlapping data points, indicated that response card use had an effect on the level of their on-task behavior. All students, however, did show a change in level during the second DRC condition. Due to the variability and overlap among all other students' data, only Salmon and Jonah showed three basic demonstrations of effect and a functional relation between DRCs and on-task behavior. Third, only Salmon showed strong differential effects between HR and DRC conditions for off-task behavior. Salmon's data demonstrated 90% nonoverlapping data points and three basic demonstrations of effect. Similar to active engagement and on-task behavior, all students showed a change in level of off-task behavior in the second DRC condition. While this is a strong effect for most

participants, it is not consistent with the effects shown during the first DRC condition, meaning there were not three basic demonstrations of effect.

Upon visual analysis, the data show that higher levels of active engagement and on-task behavior occurred in the second DRC than in the first DRC condition. This may be because students learned how to learn with the iPad and became accustomed to its use during literacy activities, especially since the use of the iPad was novel to the students in these lessons prior to this study. Future research should monitor responding with continued use of an iPad to determine if the novelty effect deteriorated over time and if active engagement would mirror the HR condition results with continued use.

This study adds to the current literature on student response systems by replicating results from other research in elementary and middle school classrooms comparing hand-raising to response cards with high school students with mild to moderate disabilities (e.g., Berrong, Schuster, Morse, & Collins, 2007; Didion, Toste, & Wehby, 2020). The current study found the same results for active engagement during response card conditions, but the DRCs did not have the same results as traditional response cards regarding on-task and off-task behavior. Further research is needed to determine if DRCs can increase on-task behaviors or if perhaps the novelty of the iPad during lessons is a barrier to staying on-task. Also, the current study used DRCs during literacy activities. Prior research has investigated the use of response cards during calendar (e.g., Berrong, Schuster, Morse, & Collins, 2007), math (e.g., Didion, Toste, & Wehby, 2020), and social studies (George, 2010) for students with varying disabilities. By investigating response card use during literacy activities, the current study expanded

the types of activities in which response cards have been used. The current study also adds to the literature by examining high tech digital response cards.

One unique aspect of this study was the use of the Plickers application to assess pre- and post-tests in this study. The students successfully used the application in this study. Use of this application has several practical advantages for teachers in classrooms. First, because Plickers use a barcode to indicate answers, the ability to answer based on another student's answer is eliminated. In this study, since the nine participants were responding at the same time, it was imperative that students could not see other students' answers. Teachers may appreciate the use of Plickers so that they can gather data on multiple students in a group format. Second, the use of the Plickers application for assessment provides for a quick recording of responses. The teacher can use their smartphone to scan responses using the phone's camera, making assessment efficient. Third, only one electronic device is required when using Plickers. This may decrease distractions caused by student devices, because only the teacher has an electronic device. Finally, the Plickers application is free to download and use making it a good choice for schools.

Limitations to this study include the lack of randomization of the introduction of conditions across participants and lack of social validity data. First, it would have been beneficial to counterbalance the conditions to avoid possible sequencing effects. Half of the participants could have been randomly assigned to receive the DRC intervention first (B-A-B-A sequence), and the other half could have received the intervention as the second condition (A-B-A-B) to minimize this threat to internal validity. This would increase believability that the DRCs were what caused the change in active engagement

and on-task/off-task behavior. Second, no data were collected on social validity. If the researchers had surveyed the classroom teacher and students, more information about the acceptability of the goals, procedures, and outcomes of the conditions could have been assessed.

In the future, researchers may want to collect data on problem behaviors. Skylar and Jonah had BIPs already in place for challenging behaviors (i.e., self-injurious behavior and talk-outs). Past studies have used inappropriate behaviors as dependent variables and found results in decreasing those behaviors (Berrong, Schuster, Morse, & Collins, 2007; Horn, Schuster, & Collins, 2006). Since there was not a strong effect for off-task behavior, measuring problem behaviors could have added further results to the current study.

For teachers who would like to implement similar interventions, considerations would need to be made about the technology used in this study. For example, each student in the study had an iPad during DRC conditions. It can be difficult for special education classrooms and teachers in general to have access to that many devices at one time if their school does not have a one-to-one technology program that gives each student their own device such as an iPad or Chromebook. Teachers also should consider the individual learning characteristics to determine if technology is the best option for their students. For example, some students may react positively to the novelty of the device, whereas others may be distracted by the device. Teachers must also be prepared to troubleshoot the technology, keep the devices in working order, and provide for an alternative response format if the technology fails.

Overall, the results of this study show a functional relation between the use of DRCs and active engagement in literacy instruction with individuals with mild and moderate disabilities. More data are needed to determine if the effects maintain over time with repeated use of the technology. Additionally, more data are needed to determine if the use of DRCs result in more learning, which should be the the primary consideration for teachers using the technology.

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