Does the Establishment of Conditioned Reinforcement for Narrative Reading Affect STEM Reading or Vice Versa?

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Abstract

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Research has demonstrated the positive effects on reading achievement measures when content is conditioned as a reinforcer for prolonged reading. While previous research has focused on conditioning narrative texts on the relation to increased comprehension, there is no current research on the effects of conditioning informational texts. Experiment 1 examined whether the effects of conditioning narrative texts as a reinforcer extends to technical writing for science, technology, engineering, and math (STEM) content for third graders with and without Individualized Education Plans. We replicated the conditioning procedures used with elementary-aged participants in previous studies for narratives texts. Using a four-step, peer-collaborative procedure, peer interactions were paired with reading activities to condition narrative texts as reinforcers for prolonged reading. Results indicated that reinforcement value of conditioned narrative texts did not transfer to STEM texts. Experiment 2 examined whether the effects of conditioning STEM texts as reinforcer extends to narrative texts. Academic achievement was also measured after conditioned reinforcement for STEM texts was established using the four-step peer collaborative procedure. Results indicated that the reinforcement value for STEM texts did not transfer to narrative texts.

Keywords: conditioned reinforcement, narrative, pairing, peers
Table of Contents

List of Charts, Graphs, Illustrations ........................................................................................................ iv

Acknowledgments ........................................................................................................................................ vii

Dedication .................................................................................................................................................... x

Chapter 1: Reading as a Predictor of Academic Success ................................................................. 1

1.1 Reading Research from the Literacy Perspective ................................................................................. 1

1.1.1 Simple View of Reading ............................................................................................................. 2

1.1.2 Cognitive Processes Within the Simple View of Reading ......................................................... 3

1.1.3 Reading Motivation and Engagement ....................................................................................... 4

1.2 Reading Research from the Behavior Analytic Perspective ........................................................... 7

1.2.1 Conditioned Reinforcement for Reading ............................................................................... 7

1.2.2 Conditioned Seeing ................................................................................................................. 12

1.2.3 Experiment 1 Research Questions ......................................................................................... 14

1.2.4 Experiment 2 Research Questions ......................................................................................... 14

Chapter 2: Does Increasing the Reinforcement Value for Narrative Texts Result in Increased Reinforcement Value for STEM Texts? ...................................................................................... 15

2.1 Method .............................................................................................................................................. 19

2.1.1 Participants ............................................................................................................................... 21

2.1.2 Setting ....................................................................................................................................... 21

2.1.3 Materials and Equipment ....................................................................................................... 22

2.1.4 Dependent Variable ............................................................................................................... 23

2.1.5 Measurement .......................................................................................................................... 24
Chapter 3: Does Increasing the Reinforcement Value for STEM Texts Result in Increased Reinforcement Value for Narrative Texts?

3.1 Method

3.1.1 Participants

3.1.2 Setting

3.1.3 Materials and Equipment
3.1.4 Dependent Variable ................................................................. 56
3.1.5 Measurement .......................................................................... 56
    3.1.5.1 Woodcock-Johnson IV Tests of Achievement Subtests .......... 57
3.1.6 Interobserver Agreement and Treatment Fidelity ....................... 57
    3.1.6.1 Interobserver Agreement .................................................... 58
    3.1.6.2 Treatment Fidelity ............................................................ 63
3.1.7 Independent Variable ............................................................. 63
3.1.8 Procedure .............................................................................. 63
    3.1.8.1 Pre-Intervention Probes .................................................... 63
    3.1.8.2 Intervention: Conditioned Reinforcement Via Peer Collaboration .... 63
    3.1.8.3 Post Intervention Probes .................................................. 63
    3.1.8.4 Interobserver Agreement ................................................. 63
3.1.9 Experimental Design .............................................................. 63
3.2 Results ...................................................................................... 63
    3.2.1 Conditioned Reinforcement for Reading ................................. 64
    3.2.2 Reading Achievement .......................................................... 77
3.2 Discussion ............................................................................... 80
Chapter 4: General Discussion ........................................................ 80
4.1 Major Findings .......................................................................... 82
    4.1.1 Conditioned Reinforcement for Narrative and STEM content ......... 82
    4.1.2 Academic Achievement ....................................................... 83
4.2 Limitations and Future Research ................................................ 84
References ..................................................................................... 86
List of Tables and Figures

Table 1 ........................................................................................................................................20

Description of Participants ........................................................................................................20

Table 2 ........................................................................................................................................26

Researcher Script and Treatment Fidelity Checklist .................................................................26

Figure 1 .......................................................................................................................................36

Peer-Collaborative Intervention Procedure Flow Chart .........................................................36

Figure 2 .......................................................................................................................................39

Conditioned Reinforcement for Reading Narrative Text Probes ............................................39

Figure 3 .......................................................................................................................................44

Average Pre- and Post- Intervention Conditioned Reinforcement Responding ....................44

Table 3 ........................................................................................................................................54

Description of Participants ........................................................................................................54

Table 4 ........................................................................................................................................58

Researcher Script and Treatment Fidelity Checklist .................................................................58

Figure 4 .......................................................................................................................................62

Peer-Collaborative Intervention Procedure Flow Chart .........................................................62

Table 5 ........................................................................................................................................64

Minutes Read During Intervention by Dyad ............................................................................64

Figure 5 .......................................................................................................................................72

Conditioned Reinforcement for Reading STEM Text Probes – Group ....................................72

Figure 6 .......................................................................................................................................73

Conditioned Reinforcement for Reading STEM Text Probes – Group 2 .................................73
Figure 7………………………………………………………………………………………………..76
*Average Pre- and Post- Intervention Conditioned Reinforcement Responding* …………..76

Figure 8………………………………………………………………………………………………..78
*Woodcock-Johnson IV Passage Comprehension Scores*……………………………………..78

Figure 9………………………………………………………………………………………………..79
*Woodcock-Johnson IV Synonym and Antonym Scores*………………………………………..79
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Dedication

Mom and Dad: I am forever grateful to have you as my parents. Thank you for the unconditional love, support, and generosity you have given to me and everyone you meet. Love you both forever.
Chapter 1: Reading as a Predictor of Academic Success

Reading is a skill that is required to be successful in school and the world beyond. Developing strong reading skills as an early elementary student is a strong predictor of future academic success (Lesnick et al., 2010). Beyond the necessary literacy skills required to develop a strong reading repertoire, another important facet of reading is reading engagement. Multiple studies have found that reading engagement and reading performance are statistically correlated (Guthrie et al., 2007; Guthrie & Wigfield, 2000; Wigfield et al., 2008). The Organisation for Economic Co-Operation and Development (OECD) created an international assessment, The Programme for International Student Assessment (PISA), that measures academic achievement and engagement globally. Since 2000, the OECD conducts the PISA every three years with 15-year-olds across 79 countries. Historically, PISA results demonstrate an association between higher index for reading enjoyment, or engagement, and higher reading performance scores (OECD, 2010). In the most recent PISA (2018), the United States scored 13th out of 79 sampled countries in reading performance, 50 points behind China, the highest performing country (OECD, 2019).

The PISA conducted an additional assessment beyond pure academic performance, one that measured students’ comments about their reading engagement. Researchers developed a questionnaire to target student perceptions on reading motivation, interest, and engagement (OECD, 2019). Students answered questions on a Likert scale with four potential responses: strongly disagree, disagree, agree, and strongly agree. Overall, the United States scored 24th out of 73 participating countries in overall reading engagement (OECD, 2019). Of the sampled US students, 54.9% agreed/strongly agreed with the statement, “I only read if I have to”, while 33% agreed/strongly agreed with the statement, “Reading is one of my favorite hobbies” (OECD,
2019). 72% of students disagreed/strongly disagreed with the statement, “For me, reading is a waste of time”, but 46% of students disagreed/strongly disagreed with the statement, “I only read to get information that I need” (OECD, 2019). While US students don’t enjoy the process of reading, they understand the function of it.

As demonstrated above, the United States has a major problem with reading engagement. A large portion of US students view reading as an undesirable task that is used only when needed. The literature is clear that reading engagement is a crucial component of reading achievement (Guthrie et al., 2007; Guthrie & Wigfield, 2000; Wigfield et al., 2008). Educators must develop measures that increase both academic reading skills as well as reading engagement.

1.1 Reading Research from the Literacy Perspective

1.1.1 Simple View of Reading

A prominent reading theory that is prevalent in educational and reading research is the Simple View of Reading (SVR). Within SVR, there are two components: decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). SVR posits that both components are equally important to the reading process; one alone would not lead to effective reading. Reading researchers define decoding as “efficient word recognition” (Hoover & Gough, 1990). Decoding requires that child relates the printed representation of the word with the corresponding pronunciation. Children who can accurately decode can apply phonological sounds to printed novel letter combinations. Linguistic comprehension is taking lexical information and creating interpretations from that information. It extends to reading comprehension when the information is presented in written form. SVR posits that poor reading performance can be explained by a deficit in either decoding or linguistic comprehension (Hoover & Gough, 1990). This results in three categories of struggling readers: 1). those with
adequate decoding skills, but lower linguistic comprehension skills, 2). those with adequate linguistic comprehension skills, but lower decoding skills, or 3). those that demonstrate lower decoding and linguistic skills (Hoover & Gough, 1990). SVR does not recommend specific methodology on how to increase these skills but creates a theoretical framework on how to approach struggling readers.

1.1.2 Cognitive Processes Within the Simple View of Reading

Cognitive developmental psychologists attribute reading performance to multiple cognitive processes. These cognitive processes include phonological processing, semantic processing, orthographic processing, metacognition, and working memory (Hohlfeld et al., 2015; Swanson & Alexander, 1997). Phonological processing refers to the “association between sounds with letters” and “the understanding of grapheme-phoneme conversion rules and the exceptions to these rules” (Siegel, 1993, p. 38). Semantic processing involves the understanding of word meaning and orthographic processing involves the understanding of spelling and writing conventions for a language (Swanson & Alexander, 1997). While difficult to fully measure the effects of semantic and orthographic processing on reading comprehension, the prevailing theory is that children with difficulty representing a visualization to match the vocal or written word have a delay in semantic processing (Swanson, 1987). Metacognition is an important cognitive process that represents a reader’s ability to self-monitor their own comprehension and make appropriate adjustments while reading to increase their own comprehension (Chevalier et al., 2017; Wong, 1991). Metacognition can manifest as recognizing when a word meaning is unknown and then using clues about the structure of the word and contextual elements within a sentence to assist with defining that word. Lastly, working memory is a cognitive process that allows readers to hold information within their short-term memory as they continue executing
other cognitive processes (Peng et al., 2018; Perfetti, 1985). Researchers find working memory to be especially important to reading comprehension, as the inherent nature of reading requires the reader to hold on to past information as they acquire new information.

1.1.3 Reading Motivation and Engagement

A crucial aspect to literacy development that is not included directly within the theoretical construct of reading development is reading motivation and engagement. Recent literacy research approaches reading engagement under multi-component models including behavioral, cognitive, and affective, or emotional, constructs (Fredricks et al., 2004, 2011).

Behavioral engagement is usually measured through participation or active time engaged in reading. Guthrie et al. (2012) included behavioral indicators of reading including student self-reports of time spent reading and individual self-reporting on engagement scales. Participants were asked to report on their perceived attention, concentration, effort, and negative behavioral engagement (pretending to work). The notion of behavioral engagement in reading is tied to cognitive science. Reading is a cognitively taxing process that requires the integration of multiple cognitive processes (automatic and rapid word processing, sentience level integration, inferencing, and reasoning) (Kendeou et al., 2007). Because of the effortful and demanding nature of these processes, attention and effort towards the reading process is required to develop any level of true competence (Ericsson et al., 1993). As these processes develop the sustained practice of reading leads to increased cognitive proficiency, as well as the inverse (Guthrie et al., 2012). Guthrie et al. (2012) also notes that the interest within the individual text itself, or the perceived importance of the text, can act as an intrinsic motivator to engaged in prolonged reading.
Cognitive engagement encompasses an individual’s “willingness” to engage in the reading process and the level of internal “investment” the individual puts forth (Fredricks et al., 2011; Guthrie et al., 2012). These measures are more difficult to measure than behavioral engagement, as they are not outwardly observable. Researchers use a variety of self-report measures that contain items assessing self-regulation and cognitive strategies employed during reading. Affective engagement includes the emotions and feelings that enable student to engage in an activity, like reading (Lee et al., 2021). One’s affective engagement is impacted by both positive and negative emotional experiences in relation to reading (Cook et al., 2020). Affective engagement is also measured through self-reporting. These scales measure an individual’s emotions and feelings that contribute to engaged reading (Lee et al., 2021). When affective engagement is high, individuals report positive emotional experiences associated with reading, illuminating an underlying internal motivation to maintain behavioral engagement with reading (Cook et al., 2020).

Lee et al. (2021) conducted a meta-analysis of 60 reading engagement studies. Their findings determined that most reading assessments (43%) focused on the behavioral engagement construct. Seventy-seven percent of the examined studies were studying the effect of antecedents, interventions or instructional practices, on increasing reading engagement. Most studies do not explicitly address the genre of the text used when measuring engagement. Of those that do reference genre, more studies focus on literature, or narrative, texts (13) than informational texts (8) (Lee et al., 2021).

Interventions to address reading engagement vary. Common methods to increase reading engagement are Sustained Silent Reading and Concept-Oriented Instruction (CORI). Sustained Silent Reading (Hunt, 1984) is a period allotted throughout the day where individuals can self-
select desired material and read without any restrictions. There is no real instructional element to the procedure. The theory behind the practice is to provide time that individuals can engage in reading in their desired way, as opposed to potentially aversive reading instructional times within the classroom (Bryan et al., 2003). CORI is a class-wide, teacher-led intervention that provides scripted lessons with embedded motivational engagement strategies (Rosenzweig et al., 2018). The lessons include practices that increase reading comprehension, provide choice when reading to increase intrinsic motivation, and provide tasks that require peer collaboration to increase social motivation to engage in reading (Rosenzweig et al., 2018).

Two other reading intervention practices that require peer collaboration included Reciprocal Reading, and Peer-Assisted Learning Strategies (PALS). These strategies are not generally studied under the reading engagement umbrella but have a component of social motivation embedded within. Reciprocal Reading involves teaching participants four reading strategies that increase reading comprehension (predicting, questioning, clarifying, and summarizing). Peers then complete reading tasks, applying each of the reading strategies, and providing feedback on the execution of each strategy (Cockerill et al., 2022; Thurston et al., 2020). Reciprocal Reading has proven to be an effective strategy in increasing reading comprehension, but few studies measure its effect on reading engagement (Cockerill et al., 2022; Thurston et al., 2020).

The PALS intervention contains three structured activities: partner reading with retell, paragraph shrinking, and prediction relay (Lee, 2014). PALS is primarily viewed as effective reading intervention but does have evidence of increasing academic engagement (Lee, 2014; Sinclair et al., 2019). Lee (2014) found that group receiving the PALS reading intervention demonstrated significant improvement towards reading attitude in comparison with the control
group. Sinclair et al. (2019) additionally found that the implementation of PALS within the classroom led to decreased disruptive behavior and increased academic engagement, measured by researcher observation. Both PALS and Reciprocal Reading not only address reading comprehension but also address motivation and engagement through peer collaboration.

### 1.2 Reading Research from the Behavior Analytic Perspective

Behavior analysts derive their theory from Skinner’s theory of operant conditioning (Skinner, 1938). Behavior changes over time, by increasing or decreasing, because of reinforcement or punishment. Varying stimuli in a human’s environment maintain reinforcing or punishing value, like the punishing exposure to an electric shock or the reinforcing exposure to a hug and a pat on the back. Behavior analytic research on reading engagement is also approached through the lens of conditioned reinforcement and verbal behavior (Catania, 2007; Greer & Ross, 2008; Ross & Greer, in press). When selecting a book amongst other competing reinforcing stimuli, attending to a book, and engaging in sustained reading behavior with varying textual content, all are under the control of the reinforcement value of reading.

#### 1.2.1 Conditioned Reinforcement for Reading

Initially, a child must demonstrate conditioned reinforcement for selecting books during unstructured free time. Buttigieg & Greer (accepted) implemented both operant conditioning and stimulus-stimulus pairing procedures with preschoolers to increase the reinforcing value of books. Researchers taught participants sight words to mastery, pairing the accuracy of reading coupled with teacher praise with textually responding. If participants did not increase their preference towards books during free play, researchers implemented a stimulus-stimulus pairing procedure in a pair/test format. Participants received a 5 s pair interval, where researchers paired praise and physical touch with observing books. Within each pair trial there were two to three
pairings delivered. Immediately upon the termination of the pair interval, researchers implemented a 5 s test interval. If participant continued to observe books, the test was successful, and another pair interval was implemented. If the participant did not observe books, the researcher immediately stopped the test interval and implemented an additional pair interval. Pairings intervals increased from 5 s to 10 s, while maintaining the two to three pairings within each interval until participants demonstrated criterion. Once participants met criterion, they received probes measuring the number of intervals in a 5 min recording period that participants selected books amongst other competing reinforcers. If participants did not meet criterion under stimulus-stimulus pairing conditions, they underwent textual operant conditioning interventions (Buttigieg and Greer, accepted).

Stimulus-stimulus pairing and operant conditioned were not only used to increase the reinforcing value of books in general but has also been used to increase the reinforcing value print symbols within books (Buttigieg, 2021; Delgado et al., 2009; Greer et al., 1982; Tsai & Greer, 2006). Further research used conditioning by denial to increase the reinforcing value of books (Singer-Dudek et al., 2011). Participants observed their peers gain access to books, while being denied access. Creating an environmental deprivation increased the reinforcement value of books. Recent research measured the effects of vicarious reinforcement on the establishment of conditioned reinforcement for observing books (Chang, 2021). Participants also were denied access to books but observed their peers interacting with books while receiving praise. Not only was conditioned reinforcement for books established, but an increased rate of acquisitions of textually responding to sight words also occurred (Chang, 2021).

A series of studies (Bly & Greer, 2019; Cumiskey-Moore; 2017, Gentilini and Greer 2020, 2021) were conducted to test the establishment of conditioned reinforcement for reading
narrative content by measuring intervals of reading during 10-to-20-minute silent reading sessions. This intervention was developed for students who could already read to some extent, while the conditioning interventions for beginning reading involved observing book stimuli prior to learning to read. Researchers measured the establishment of the conditioned reinforcement through reading probes. Researchers defined reading behavior as back and forth eye movement, starting at the left side of the page, moving to the right, and returning to the left. Researchers measured reading behavior using whole interval recording, where accurate intervals were recorded upon the emission of reading behavior for the entirety of the interval. Additional pre-intervention measures, passage comprehension and synonym/antonym subtests from the Woodcock-Johnson IV (WJIV) and i-Ready diagnostic exams were used to measure the academic responding of participants before narrative texts were established as a conditioned reinforcer. Researchers used a shared reading procedure where reading narrative texts was paired with the social reinforcement of reading with either a peer or teacher. Depending on the age of the population, participants were paired with a peer or a teacher.

Cumiskey-Moore’s (2017) unpublished dissertation implemented a peer-collaborative procedure with fifth graders that was designed to utilize reinforcement value of peer socialization as an age-appropriate intervention to condition the content of reading for upper elementary grade students. The procedure included a peer-yoked contingency that was also used as a pairing procedure. A peer-yoked contingency is a strategy used to target motivational operations (Rothstein & Gautreaux, 2007). Within this study, participants are paired together and compete to move up a gameboard, through accurate responding. The gameboard acts to increase participant motivation and acts as another form of pairing to increase reading engagement. The procedure potentially incorporated operant procedures, pairing procedures, and conditioned
reinforcement by denial component in the sequence of the intervention. The peer-collaborative intervention included four steps: 1) reciprocal reading, or shared reading, 2) selection of reinforcing textual stimuli, or defining words with unknown meaning, that were read within the reciprocal reading phase and discussing with peers, 3) independent reading, and 4) comprehension drawing task (to enhance conditioned seeing for reading content), where participants draw scenes from the text and guessed which scene their partner drew. Bly’s (2019) dissertation and Gentilini and Greer’s (2020, 2021) were systematic replications of Cumiskey-Moore’s (2017) dissertation with modifications for differences in ages and testing shared versus independent reading as part of the intervention.

Bly (2019) also ran a peer-collaborative procedure, with an embedded peer-yoked contingency, to increase the reinforcement value of narrative texts with fourth graders. Her study sought to measure the effects of shared versus independent reading throughout the peer-collaborative procedure. Bly’s (2019) results found that altering the peer-collaborative procedure to convert shared reading steps to independent reading steps resulted in higher levels of reinforcement value for reading narrative texts and overall higher reading achievement. Participants still engaged in the defining vocabulary and comprehension drawing tasks, but all reading was completed independently.

Gentilini and Greer’s (2022, 2021) studies were run simultaneously with Bly’s (2019) study and sought to determine whether peer or teacher pairings were more successful at increasing the reinforcement value for reading narrative texts with younger students. Gentilini and Greer’s (2020) study demonstrated that a collaborative shared reading procedure, with a teacher resulted in increased reinforcement value for narrative texts of second grade students more than the effect with peers, although both the peer and teacher procedures were effective. The intervention
included a yoked contingency between teacher and student. Gentilini and Greer’s (2021) study examined the differences between a peer-collaborative reading procedure and a shared reading procedure with a teacher on the reinforcement value of reading narrative texts because the participants were younger, and peers appeared to be not as reinforcing as they were to upper elementary students. The study, conducted with second graders, revealed that a teacher-student pairing resulted in higher levels of reinforcement when compared to peer-peer pairing during intervention (Gentilini & Greer, 2021). Yoked contingencies, with either teacher or peer, respectively, were embedded within each intervention. The results indicate that peers have varying levels of reinforcement, depending on age of the participant. It appears that younger participants demonstrate preference for teachers over peers, while older elementary aged students prefer peers to teachers. Researchers must select the most salient reinforcer when conducting pairing procedures for stronger effects. Across all three studies, the establishment of narrative texts as a conditioned reinforcer increased academic responding on the passage comprehension and synonym/antonym subtests of the WJIV (Cumiskey-Moore, 2017).

All three studies measured conditioned reinforcement slightly differently depending on age-appropriate time spent reading. Cumiskey-Moore (2017) measured the reinforcement value of reading narrative texts via 20 min observations of participants reading. Researchers recorded observational data using whole interval recording in 10s intervals. Bly (2019) also measured the reinforcement value of narrative texts using 20 min observations of participants reading. She used 10 s whole interval recording to measure reading behavior within the 20 min observation period. Both Gentilini and Greer (2020, 2021) studies measured the reinforcement value for narrative texts during a 10 min observation period. They used 5 s whole interval recording to measure reading behavior throughout the 10 min observation.
1.2.2 Conditioned Seeing

Conditioned seeing, a Skinnerian term, describes the process of “seeing” stimuli as a within-the-skin behavior (Skinner, 1957). Essentially, a person can not only see stimuli that are physically present within their environment, but also under other environmental contingencies, like the presence of previously paired stimuli (Skinner, 1957). For example, the sound of the local ice cream truck has been paired with the delivery of ice cream in the past. A human can hear the whimsical songs of the truck and “see” the ice cream that is evoked by the song. Skinner (1957) expands his definition of conditioned seeing to include other sensory experiences, such as olfactory, gustatory, and auditory, and tactile manifestations. Perhaps the individual not only sees the ice cream after hearing the chimes of the ice cream truck, but also experiences gustatory sensations aroused from ice cream in the past. Skinner (1957) states, “seeing the image within one’s own skin, in the absence of a visual stimulus, can evoke a response that can affect the behavior of the individual.”

Skinner goes beyond the basic notion of conditioned seeing and relates it to seeing while reading. Individuals read simple words and phrases and conjure the images in their mind. For example, a reader encounters “the brown dog” and can “see” a brown dog. The reader comes under the stimulus control of relating textual responding to visual stimuli. When conditioned seeing is present, then individuals experience emotional reactions evoked from the text, after seeing the events unfold within the skin (Skinner, 1957; Greer & Ross, 2008).

Mercorella (2017) tested an intervention to increase conditioned seeing and reading achievement for typically developing third graders. Participants created picture storyboards to match narratives, using an online software Storyboard That, then used those narratives to answer comprehension questions about the narratives within the intervention. Researchers provided
feedback on aspects of the storyboard to ensure accuracy. For incorrect storyboard aspects, researcher referred to the text that correlates with the storyboard, linking the physical text with the image created. Participants then completed drawing responses linked to stimuli they received exposure to during Naming probes. Teachers then provided learn units until the participants demonstrated mastery (Albers & Greer, 1991). They also completed pre and post comprehension questions on grade level passages. Participants increased their delayed drawing responses and comprehension question accuracy after the creation of the storyboard.

The verbal behavior developmental theory values teaching the structural components required to read, but also realizes the importance of increasing the reinforcing value of books. Before one can read and comprehend text, they must first select out books, observe books, engage with books appropriately, and then enjoy reading varying types of books. These behaviors are all behaviors that involve stimulus control and can be induced using varying stimulus-stimulus pairing or operant conditioning procedures.

Therefore, the current studies seek to examine the effects of a peer-collaborative reading procedure on increasing the reinforcement value of reading narrative and science, technology, engineering, and mathematics (STEM) texts. The relationship between conditioned reinforcement for narrative and STEM texts is unclear. The current studies also seek to determine if the reinforcement value for one text type can transfer to another. Research was conducted with third grade students whereas other studies involved second graders (Gentilini & Greer 2020, 2021), fourth graders (Bly, 2019), and fifth graders (Cumiskey-Moore, 2017).

Pulling from the results of Gentilini and Greer (2021), researchers used a peer-collaborative procedure because peer collaboration held a higher reinforcement value than working with the teacher. Additionally, researchers altered the peer-collaborative procedure to contain two
independent reading blocks, eliminating the reciprocal reading procedure in response to Bly’s (2019) findings. Reinforcement value for reading was measured over a 15 min period, between Gentilini and Greer’s (2020, 2021) 10 min period with second graders and Bly’s (2019) 20 min period with fourth graders. Researchers measured reading behavior using 5 s whole interval recording, a more stringent form of measurement.

1.2.3 Experiment 1 Research Questions

Experiment 1 sought to answer the following questions:

1. Does the peer-collaborative intervention increase the reinforcement value of reading narrative texts with third graders with and without disabilities similarly to previous studies conducted with participants of different ages and does it increase the reinforcement value for STEM texts?

2. Does increasing the reinforcement value of narrative texts result in increased reinforcement value of STEM texts?

1.2.4 Experiment 2 Research Questions

Experiment 2 sought to answer the following questions:

1. Does a peer-collaborative intervention increase the reinforcement value of reading STEM texts with third graders with and without disabilities and does it increase the reinforcement value for narrative texts?

2. Does increasing the reinforcement value of STEM texts result in increased reinforcement value of narrative texts?
Chapter 2: Does Increasing the Reinforcement Value for Narrative
Texts Result in Increased Reinforcement Value for STEM Texts?

Students in the United States consistently underperform in reading, math, and science measures, when compared to students from other countries (Organisation for Economic Co-operation and Development, 2018; U.S. Department of Education, 2017). The 2018 Programme for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development, revealed that the U.S. ranked 13th in reading achievement out of 78 participating countries (Organisation for Economic Co-operation and Development, 2018). U.S. student performance in math and science measures fall well below the global average. The National Assessment of Education Progress (NAEP) conducts a national assessment every two years to determine academic proficiency of various contents for 4th, 8th, and 12th graders. The most recent assessment, conducted in 2019, concluded that a mere 35% of 4th graders, 4% of 8th graders, and 37% of 12th graders were performing on or above level deemed Proficient by the NAEP, demonstrating a decrease in performance for 4th and 8th graders on the 2017 assessment (37% and 36%, respectively). The national performance of 12th graders remained the same form 2017 to 2019, at 37% at or above Proficient. To continue to engage meaningfully in a global society, the United States is faced with the burden of improving their education system. At the heart of all academic studies lies reading. Improving the reading skills of American children will equip them to become independent learners that continue to expand their expertise through the act of reading.

Current teaching practices focus on the most recent best practices that produce effective readers, incorporating reading engagement strategies. McGeown et al. (2015) approaches research effective reading practices through the lens of how self-reporting of motivation impacts
reading performance. The 2015 study found that reading motivation increases attention to the reading task (measured through scaled self-reports) and results in increased comprehension of the text. Additional studies support the notion that increased reading interest leads to increased reading achievement (Askov & Fishbach, 1973; Kirby et al., 2011; McKenna et al., 1995). The interventions used to increase reading attitude or interest, all have a similar component embedded within - the use of collaboration within the intervention (Pittman et al., 2014; Springer et al., 2017; Mujib et al., 2022). Mujib and Setyawan’s 2022 study implemented a reading challenge to increase reading interest. Throughout the study, participants read aloud to researchers. The participant who read the most books in a month was awarded a prize. Pittman and Honchell’s 2014 study implemented literature discussion groups (LDGs) where peers engaged in collaborative discussion and analysis of literature texts. Both interventions, while effective, demonstrate varying forms of stimulus pairings. Repeated stimulus-stimulus pairings occur between researcher and participant in Mujib and Setyawan’s study (2022), while repeated pairings between peers occurred in Pittman and Honchell’s study (2014). Reading researchers implement effective interventions to increase reading interest and subsequent academic achievement, while an unknowing behavior analytic root.

Behavior analytic researchers have conducted considerable research on the interest in reading, known as (a) conditioned reinforcement for observing books for learning to read (Tsai & Greer, 2006; Pereira-Delgado et al., 2009) and (b) conditioned reinforcement for content for students reading to learn (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). At the most basic level, research on conditioned reinforcement using stimulus-stimulus pairing procedures has demonstrated increased reinforcement for observing responses to a range of stimuli, including 2D stimuli, 3D stimuli (Greer & Han, 2014; Pereira-Delgado et al., 2009),
voices (Greer et al, 2011) and faces (Maffei-Lewis et al., 2014; Speckman et al., 2017). These procedures, primarily conducted with students demonstrating low observing responses and with minimal verbal developmental cusps in repertoires, pair an unconditioned reinforcer with a conditioned reinforcer. Within these studies, the conditioned reinforcer was usually a primary reinforcer, such as food, or a previously conditioned reinforcer, like researcher praise and touch. Using a pair-test procedure, researchers delivered 5 s pair intervals, pairing the unconditioned reinforcer with the delivery of the conditioned reinforcer followed by 5 s test intervals. Test trials were only done when the participants demonstrated continuous observation during the pairing trials. If they did not the pairing trials was repeated until successful. During the test interval, researchers recorded whether the participant actively selected and engaged with the target stimulus throughout the 5 s. Once participants demonstrated successful 5 s observing responses for blocks of 20 test trials, they were tested under free play conditions. If they did not meet the free play criterion the pair test trials were increased by 5 s to 10 s. Through repeated pair-test trials, the target stimuli became a conditioned reinforcer across all studies (Pereira-Delgado et al., 2009; Maffei-Lewis et al., 2014; Speckman et al., 2017).

Basic pairing procedures have been found effective to increase a child’s conditioned reinforcement for attending to and selecting books, measured as the number of whole 5 s intervals participants selected books among other competing reinforcers in a free play setting where other activities and toys were available (Tsai, 2006). Results also found that increased conditioned reinforcement for observing and selecting books increased rate and accuracy of learning to textually responding to varying word sets (Tsai, 2006).

For students who can read and are reading to learn, conditioning reading content of narrative texts has increased student reading achievement levels on multiple standardized
measures (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). Cumiskey-Moore’s (2017) unpublished dissertation conditioned reading narrative texts using a peer pairing procedure with fifth graders. Cumiskey-Moore increased reinforcement value of reading narrative texts, such that participants read for 80% of 20 min sessions. The increase in reinforcement value resulted in increased performance on comprehension and vocabulary measures on standardized reading tests. Bly’s unpublished dissertation (2019) conducted the same procedure using peer pairing procedures with fourth graders and replicated Cumiskey-Moore’s findings. Cumiskey-Moore and Bly both measured the reinforcement value as duration of observing books, using a continuous 10 s whole interval recording measurement system to determine the number of intervals participants read. Both unpublished dissertations informed the recently published Gentilini and Greer articles (2020 and 2021), where teacher-student pairing procedures increased the conditioned reinforcement value for reading narrative texts over 10 min reading period with second graders. Gentilini and Greer (2020 and 2021) also used a peer-yoked contingency game board as a part of the conditioning procedure, modeled after Bly’s (2019) study. The two Gentilini and Greer studies demonstrated that increasing the conditioned reinforcement value for reading narrative texts increased reading comprehension and vocabulary performance (Gentilini & Greer 2020, 2021). In the latter study, pairing procedures with the teacher was more effective than pairing procedures with peers. However, both peer and teacher pairings were effective.

These studies provide evidence for Skinner’s assertion that aesthetic (narrative) and technical (STEM) texts have different reinforcement functions, and in turn might have differences in reinforcement value for a reader (Skinner, 1957). The literature has demonstrated that reinforcement value for reading narrative content is connected to academic achievement, but
there is no research on the role of reinforcement value of technological, or STEM, texts. It is unclear whether increasing the reinforcement value for narrative texts results in increased reinforcement value for technological, or STEM texts. Researchers are unsure of whether the conditioning of a specific content is transferable to other content types and whether there will be comparable academic gains demonstrated as has been shown when conditioning narrative texts (Bly, 2019; Cumiskey-Moore, 2017; Gentilini and Greer, 2020, 2021)

The current study is a systematic replication of Bly’s (2019) unpublished dissertation, adding an additional dependent variable, the reinforcement value of STEM texts.

This study sought to answer the following questions:

1. Does the peer-collaborative intervention increase the reinforcement value of reading narrative texts with third graders with and without disabilities similarly to previous studies conducted with participants of different ages and does it increase the reinforcement value for STEM texts?

2. Does increasing the reinforcement value of narrative texts result in increased reinforcement value of STEM texts?

2.1 Method

2.1.1 Participants

Six third graders between the ages 8 years, 2 months and 10 years participated in the study (see Table 1 for participant information). The study was conducted in a Title-1, public elementary school outside of a major metropolitan area. Participants were selected from a general education classroom that used the Comprehensive Application of Behavior Analysis to Schooling (CABAS®) and Accelerated Independent Learner model of education (Greer, Keohane, & Healy, 2002). The classroom participants received individualized instruction and
research-based tactics derived from the science of behavior analysis to accelerate learning and measure all responses to instruction. Three participants qualified for an Individualized Education Program (see Table 1 for participant information). The eligibilities across all participants ranged from Specific Learning Disability and Other Health Impairment (Attention-Deficit/Hyperactivity Disorder). Five participants were female, and one participant was male. All participants were selected for this study because they tested below grade level either on the district provided *i-Ready K-12 Adaptive Reading Diagnostic Assessment* (Curriculum Associates, LLC, 2017) or on the *Developmental Reading Assessment* (DRA) (Pearson Education, 2006). Four of the six participants overall scores on the *i-Ready K-12 Adaptive Reading Diagnostic Assessment* were below-grade level. Five of the six participants demonstrated below grade level scores on subtests in vocabulary, literature comprehension, and informational comprehension subtests. All participants demonstrated below grade level performance on the DRA (see Table 1).

**Table 1**

*Description of Participants*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>ELL</th>
<th>Diagnosis</th>
<th><em>i-Ready</em> Literature Text subtest score</th>
<th><em>i-Ready</em> Informational Text subtest score</th>
<th><em>i-Ready</em> Vocabulary subtest score</th>
<th>DRA Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.10</td>
<td>Female</td>
<td>N</td>
<td>ADHD</td>
<td>Early 3</td>
<td>Early 3</td>
<td>Late 3</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>9.5</td>
<td>Female</td>
<td>Y</td>
<td>Specific Learning Disability</td>
<td>Grade 1</td>
<td>Grade 2</td>
<td>Grade 2</td>
<td>28</td>
</tr>
<tr>
<td>C</td>
<td>8.7</td>
<td>Female</td>
<td>N</td>
<td>Specific Learning Disability</td>
<td>Grade 2</td>
<td>Grade 2</td>
<td>Grade 1</td>
<td>24</td>
</tr>
<tr>
<td>D</td>
<td>10.0</td>
<td>Female</td>
<td>N</td>
<td>-</td>
<td>Grade 2</td>
<td>Grade 2</td>
<td>Grade 2</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Name</td>
<td>Grade</td>
<td>Early</td>
<td>Grade</td>
<td>Mid</td>
<td>Years</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Female</td>
<td>Grade 2</td>
<td>Grade 2</td>
<td>Mid 3</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Male</td>
<td>Early 3</td>
<td>Early 3</td>
<td>Grade 2</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* ELL refers to English Language Learner status. Y means they receive services as English Language Learners. Early 3 is considered on grade level. Grade 1 or 2 means the participant is the associated number of years behind grade level. Mid 3 equates to performing as a third grader who completed half of their third-grade year. Late 3 equates to performing as a third grader who finished most of their third-grade year. DRA refers to *Developmental Reading Assessment*.

### 2.1.2 Setting

Different components of the study were run at different areas of the classroom. During conditioned reinforcement probes participants sat at a U-shaped table within the classroom in pairs. The other students in the class were engaged in a reading or writing task at their individual desks while researchers conducted and video-recorded probes. Researchers recorded a 16 min reading session using the camera function on an iPhone placed roughly 1 m away from the participants on a tripod.

Researchers ran the four-step peer collaboration intervention at a 0.9 x 1.2 meters table in a room adjacent to the classroom. No other students were present during the peer collaborative procedure intervention. Participants sat next to each other and across from the researcher. Given the national health precautions in place to protect against COVID-19 during the months the study was conducted (January to June 2021), procedures within this study were adapted to fulfill CDC guidelines regarding social distancing. Participants sat 1 m apart on the same side of the table, while wearing masks, throughout the intervention.
2.1.3 Materials and Equipment

Researchers conducted assessment probes to assess the reinforcement value of reading using an iPhone camera placed on a tripod. Video were stored on a password protected online storage space. Researchers utilized a whole interval recording data sheet broken into 180 5 s intervals, (Appendix A). When watching videos, researchers played aloud an online looping timer to denote the beginning and end of each interval.

Throughout the intervention, participants used a researcher-designed worksheets to complete each component of the intervention (Appendix A). Participants read one book per intervention session. Each book was between three and four pages. All texts were pulled from *Wonders* (McGraw-Hill, 2017) or *Reading A-Z* (RAZ) (*Learning A-Z*, 2002) curriculums and leveled within two DRA levels of the participants’ independent level. For each text, researchers created a pictureless version of the text. This decision was made based on findings showing teaching reading without pictures results in stronger comprehension (Mercorella, 2017). These versions of the book were printed and presented on paper to ensure only the text, without pictures, was presented to the participants.

Researchers used an online tool (www.puzzlemaker.com), to create crosswords with vocabulary featured within each story. Researchers used the highlighted or bolded words within each text as the word used in the researcher-designed crosswords. The comprehensive drawing task was directly replicated from Bly’s (2019) dissertation that involved 20 x 28 cm sheets of paper for participants to draw images of what they read (Appendix C). There was a space with lines where each participant could write the scene from the book their partner drew. Researchers used a peer-yoked contingency game board within the intervention (as described in Appendix D). The game board was presented virtually on a google slide. There were 20 slots on the
gameboard. If participants gained more than 20 points, one marker was left on the start to demonstrate a value of 20 and another marker continued to accrue additional points. Participants moved up the game board for correct collaborative responding during the collaborative conditioning procedure and gained points towards reinforcers selected from a menu after each intervention session (Appendix E).

2.1.4 Dependent Variable

Researchers measured two dependent variables: 1) reinforcement value for reading narrative texts and 2) reinforcement value for reading STEM texts. The dimension of measurement for reinforcement value was defined as the duration participants observed books during 15 min periods of time, which will further be referred to as reading. Narrative texts were identified as fictional stories that had an overarching narrative plot. STEM texts were identified as non-fiction, science texts. Researchers used biology and earth science texts within this experiment. Researchers defined reading as the participant’s eyes moving from left to right from the top to the bottom of the page, turning the page of a book once the participants’ eyes reached the bottom of the right-hand page, and selecting a new book upon completing the prior book. Researchers collected data from video recordings of participants reading during a 15 min period. Researchers recorded 16 min videos to ensure there were 180 total intervals where participants were in the frame reading. If the participant exited the frame or covered their face, the researcher skipped that interval for the participant, resuming the collection of data once the participant entered the frame again. Researchers then collected data until they collected 180, 5 s intervals. If the participants remained in the frame, with their faces visible to the camera, for the entire 15 min period, researchers stopped collecting data at the 15 min mark.
2.1.5 Measurement

2.1.5.1 Pre- and Post-Intervention Probes

To measure the reinforcement value for reading narrative content, researchers measured the dimension of duration by using continuous 5 s whole interval recording procedures. Reinforcement value for narrative and STEM texts was defined as the number of whole 5 s intervals engaged in reading during a 15 min reading period. If the participant looked at books for the entire 5 s interval, the researcher recorded a plus (+). Non-examples of looking at books includes staring at the page without left-to-right eye movement, flipping pages repeatedly, talking to peers, and looking at stimuli outside of the book. If participants did not look at books with left-to-right eye movement at any point in the interval, the researchers recorded a minus (-). During the observation period, participants often finished a book and required time to select a new book. If participants finished a book within the 15 min observation, they had two 5 s intervals to select a new book. Researchers recorded a plus (+) for these intervals, as it was considered appropriate reading behavior. If participants played with the books, looked around while touching the books, or engaged in non-reading behavior as defined above, researchers recorded a minus (-). After the conclusion of the second interval, researchers continued recording data as defined above. If participants continued to select a book past the conclusion of the second interval, researchers recorded a minus (-). Researchers totaled the number of intervals participants engaged in active reading behaviors for the entire 5 s interval over the course of the 15 min observation period (180 intervals). Mastery criterion was set for 80%, or 144 of 180 intervals, engaged in active reading behavior in one 15 min interval.

Before implementing the intervention, researchers calculated the mean number of minutes both participants read across the multiple pre-intervention probes. Researchers selected a
goal time slightly above the average time read as the duration during steps one and three of the first intervention sessions. For example, if Participant A read for an average of 1 min 32 s across all five pre-intervention probes, they would enter the intervention reading for 2 min during steps one and three. Participants were paired with the participant whose average reading time across pre-intervention probes most closely aligned to their own. If one participant in the dyad read more than the other, both participants would enter intervention reading at the goal of the participant with the lower average. For example, if Participant A entered the intervention reading for 2 min and Participant B entered intervention reading for 3 min, both participants would enter intervention reading for 2 min.

2.1.6 Interobserver Agreement and Treatment Fidelity

2.1.6.1 Interobserver Agreement

Researchers collected interobserver agreement (IOA) by having a second observer record data simultaneously and independently of the researcher using the videos recorded during probe sessions. Observer agreement is when two novel observers gathered the same data on the same interval, while observer disagreement is defined as when observers demonstrated no agreement on the same interval. Researchers calculated interobserver agreement using interval-by-interval IOA, by adding the total intervals agreement with the same observer agreements divided by the total number of intervals of agreement and disagreement. Researchers collected IOA for 27 of 88 pre-intervention probes, 31% of the sessions. The total agreement was 96% with a range of 87% - 100%. For 13 of 36 post-intervention probes, 36% of the sessions, researchers collected IOA. The total agreement was 99% with a range of 97% -100%. For 4 of 8 maintenance probes, 50% of the sessions, researchers collected IOA. The total agreement was 99.75% with a range of 99%-100%.
2.1.6.2 Treatment Fidelity

Researchers created a checklist of a script of the intervention steps in the study. The checklist was used while conducting the intervention steps, during intervention sessions, in the current study in situ. The checklist included a script and was used for every session (see Table 2). Researchers collected treatment fidelity by assigning a second, independent observer to observe intervention sessions in situ. The independent observer completed the checklist as the researcher implemented the intervention. If the researcher implemented the component according to the checklist, the observer recorded a plus (+). If the researcher did not follow the script, missed a component on the checklist, or incorrectly implemented a component, the observer recorded a minus (-). Researchers calculated the percentage of correctly followed treatment steps by dividing the total number of correctly implemented steps by the total number of steps, multiplied by 100%. Treatment fidelity was collected for 10 of 29 intervention sessions, or 34% of sessions. The total fidelity was 100% across all sessions. Table 2 shows the treatment fidelity checklist.

Table 2

Researcher Script and Treatment Fidelity Checklist

<table>
<thead>
<tr>
<th>Researcher Script</th>
<th>Researcher Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Here are the books you will use today. You will also use these pages to complete some activities”</td>
<td>Place the pictureless narrative fiction books indirectly in front of participants. Give one book to each participant. Provide crossword and drawing task papers to participants.</td>
</tr>
<tr>
<td>“Set your timer for ______ minutes. During this time, you will read silently. You will be reading all by yourself during. Ready set, start your timers”</td>
<td>Instruct participants to set and start timers to read silently and independently for the average time both participants spent reading during probe sessions.</td>
</tr>
<tr>
<td><strong>Silent reading</strong></td>
<td>Take 5-second whole interval recording data for active reading behavior. Reading behavior</td>
</tr>
</tbody>
</table>
“Turn off your timer. Pick up your pencil and underline the last word you read.”

“You are going to work together to solve some crosswords puzzles. Read the definitions on your page and match them with a word in your word bank. You must agree on the same answers. You will move up the game board for each correct response on the crossword.”

“Check your answers against the answer key. If you got the answer correct, move your character up the game board. If not, read the correct definition and word to your partner.”

“Time to silently read again. Look at the page number your partner stopped reading at. Start reading from the lower page number. Flip now to the same page. Set your timer for _____ minutes. During this time, you will read silently all by yourself. Ready set, start your timers.”

Silent reading

“Stop reading. Underline the last word you read. Look at where your partner ended. Circle the last word your partner read in your book. Look back at the pages that you and your partner BOTH read. Select a scene that you will draw. Your goal is to draw the scene with enough detail that your partner can guess the scene. You will move up the game board if you both guess correctly!”

“Now that we are done with the drawing, trade papers with your partner. Look at the drawing and find the exact sentences that

is defined as eyes moving back and forth across the page from top to bottom for the entirety of the 5-second interval.

Stop timers. Instruct participants to underline the word they stopped reading on.

Instruct students to complete the crossword puzzle.

Instruct students to correct their crosswords using the answer key. Record data on accuracy of completion of crossword puzzle. Ensure participants move up the game board.

Instruct participants to set and start timers to read silently and independently for the same number of minutes as the first silent reading block. Instruct participants to start reading where the slower reader ended.

Take 5-second whole interval recording data for active reading behavior. Active reading behavior is defined as eyes moving back and forth across the page from top to bottom for the entirety of the 5-second interval.

Instruct participants to select a scene to draw from the pages both participants read. Look at the participant with the slower reading rate and select from the pages they completed reading.

Instruct participants to close their books, trade papers, and write the paragraph or sentences of the scene their partner drew.
describe the picture. Look between pages ______ to ______. Once you find the sentences, write them on the lines provided.”

“Trade papers. Put a plus (+) if your partner wrote the sentences you used to draw your picture. Put a minus (-) if your partner wrote sentences you didn’t use to draw your picture. Give your papers back when you are done.”

Instruct participants to trade back their papers and conseuate their partners. Record data on accuracy of drawing task.

If correctly identified the scene:
• Say to the partner that selected the sentences: “Nice job selecting the correct sentences.”
• Say to the partner that drew the picture: “Nice job drawing a detailed picture that helped your partner find the right sentences.”

If incorrectly identified the scene:
• Say to the partner that selected the sentences: “Your partner is going to redraw the picture or add more details so that you can try to select the correct sentences.”
• Say to the partner that drew the picture: “Look at the sentences your partner wrote down. They don’t match your picture. Make changes to your current picture or draw a new picture so your partner will select the right sentences to match your picture.”
• “You did not move up the game board. You still have the opportunity to trade in. Select what you would like.”

If the participants both identify the correct scene, they move up the game board and can select a reinforcer at or below their position on the game board.

If one or both participants identified the incorrect scene, the participants who drew the picture must redraw the picture or add detail to the drawing until the partner guesses the correct scene. They do not move up the game board.

Repeat this correction procedure until the partner selects the correct sentences.

Increase the next intervention silent reading time by 2 minutes for both silent reading tasks IF the participants BOTH read for 80% of BOTH silent reading tasks.

After 3 increases in time, conduct a 15 min, 5 s whole interval probe for narrative texts.
2.1.7 Independent Variable

Researchers conditioned narrative texts using a four-step peer collaboration procedure. For each intervention session, this procedure included four components: (a) independent reading period, (b) crossword task, (c) second independent reading period, and (d) comprehensive drawing task. Both independent reading steps required participants to read silently and independently. The collaborative portion of the procedure occurred during steps two and four where completion of the steps required collaboration between both participants.

Researchers recorded the number of intervals participants engaged in reading during independent reading periods using the same measurement system used throughout the probe sessions. Criterion for each intervention session was reading 80% of each independent reading period. Participants met criterion when they engaged in active reading behavior for 80% of both independent reading periods for the intervention session. If participants met criterion as described under measurement, researchers increased the reading time during intervention by 2 min. The number of times the intervention reading interval was increased was used to determine when to conduct post-intervention probes. Researchers recorded the total number of sessions required to demonstrate increased conditioned reinforcement for reading narrative texts.

Accuracy on the crossword task was also recorded, measured as the number of words accurately placed in the crossword puzzle that matched the corresponding definition from each texts’ glossary. Researchers also measured correct responding on comprehensive drawing tasks if one participant identified the exact scene, or exact sentence, from the book portrayed in their partner’s hand-drawn picture.

Data was taken in-situ to make decisions about meeting criterion. During step two and four of the peer-collaborative procedure, researchers collected 5 s whole interval recording data.
on participant reading behavior in situ, using the same procedures as the probe sessions. Researchers used a 5 s looping timer set to a soft beep and recorded data contemporaneously on the same data sheet template used during dependent variable probe sessions. Participants met criterion for the intervention session if they engaged in reading behavior for 80% of both reading periods within the intervention session. The time of each reading period changed, so the number of intervals required to meet criterion changed. For example, in the 2 min intervention phase, participants read for 2 min during step two and step four. There are 12 5 s intervals in a minute so there are 24 total intervals in the 2 min intervention phase. Participants were required to read for 19 of the 24 intervals in both step two and four to meet criterion. Refer to Appendix F for a flow chart representing the steps within the peer-collaborative intervention procedure.

**2.1.8 Experimental Design**

The study used a combined pre and post intervention with multiple baseline design to determine the effects of conditioning narrative texts on increasing the reinforcement value of narrative and STEM texts. Researchers selected a multiple baseline design because the dependent variables were measures of learning (Baer et al., 1968). This design improved the internal validity of the study by controlling for history and testing. Participants all received baseline probes simultaneously. As the first dyad entered instruction, the other dyads remained in baseline. Once the first dyad demonstrated increased responding, the participants received additional baseline probes to test for continued low level of responding pre-intervention juxtaposed with the participant(s) responses in intervention. Dyads systematically entered the intervention after the previous dyad demonstrates increased responding. Researchers systematically replicated the intervention across multiple dyads to determine whether the reinforcement value of narrative and STEM texts changed because of the introduction of the
intervention. Continuous baseline measures were recorded for dyads remaining in the baseline condition. Researchers conducted pre- and post-intervention probes to determine the effect of the peer-collaborative intervention on increasing the reinforcement value of narrative and STEM texts.

2.1.9 Procedure

2.1.9.1 Pre-Intervention Probes

Researchers conducted all pre-intervention probes by seating two participants at a U-shaped table facing the experimenter. For probes on conditioned reinforcement for reading narrative content, researchers placed five to seven fiction books at the table. For probes on conditioned reinforcement for reading STEM content, researchers set five to seven biology or earth science books at the table. Researchers placed the recording device on the table, roughly 1 m from participants, ensuring both were captured in the view of the camera. The researchers informed the participants that they would be engaging in silent reading. No prompts or consequences were delivered for reading. The researchers set timer to 16 min on the Smartboard and started the recording device. Researchers set the timer for one min longer than the 15 min interval to ensure there were 180 intervals of reading recorded where the participant was in the frame with their face showing. Once the 16 min timer concluded, researchers instructed participants to return to their desks and the class began instruction. Video recordings were uploaded to a cloud storage for data to be collected later.

2.1.9.2 Intervention: Conditioned Reinforcement via Peer Collaboration

Researchers used a peer-yoked contingency game board, for all collaborative intervention components (Appendix D) Participants gained points, moving up the gameboard, for accurate completion of the intervention steps two and four. Researchers presented the virtual gameboard,
made on Google Slides, on a computer screen that participants could refer to throughout the intervention session. To earn points both participants had to accurately complete the crossword puzzle and accurately identify the exact sentence their partner drew within the comprehensive drawing task. All tasks were completed collaboratively. Both participants read the crossword clue, discussed the definition, and engaged in conversation debating the correct word choice. In the comprehensive drawing task, participants guessed the exact sentence that matched their partner’s drawing. They would vocally inform their partner if the sentence was correct or not and make edits based on their partner’s guess. The collaborative behaviors of peer interaction and discussion of the text and words was a pairing interaction between the participants and the narrative content. Participants earned one point per correctly inputted word in the crossword and two points per correctly identified passage within the comprehensive drawing task. At the conclusion of the session, participants could choose to trade in their points for a smaller, less expensive prize or save them for a larger, more expensive prize. Participants had to agree how to use their points (see Appendix E for trade-in menu).

There were four components of the intervention: 1) an independent silent reading based on pre-intervention reading time, 2) collaborative crossword puzzle task, 3) another independent silent reading based on pre-intervention reading time, and 4) a collaborative comprehensive drawing task.

2.1.9.2.1 Step 1: Silent Independent Reading. The participants sat next to each other at the U-shaped table across from the researcher. Researchers gave the participants a narrative book within two DRA levels, above or below, of both participants independent reading levels. The researcher set a timer on the table roughly 15 cm in front the participants, set to initial duration period calculated from their pre-intervention probe data. The researcher directed
participants to read independently and silently (see Table 2 for teacher script). Once the predetermined interval concluded and the timer beeped, participants stopped the timer and underlined the last word they read in the book.

2.1.9.2 Step 2: Vocabulary Task. Participants engaged in jointly completing the experimenter designed crossword to complete the crossword task (Appendix B). Researchers instructed participants to work together to use the clues to determine which words from the story fit into the crosswords (provided with accompanying word banks). Participants informed the researcher when they completed the crossword, which would result in the researcher moving the participants up one space on the yoked contingency game board per correct answer on the crossword puzzle. The crossword contained six words. Participants could earn a maximum of six points when completing the crossword task. There was no criterion for correct responding required to move to the next session. The procedure acted to pair peer interaction with unfamiliar words to increase reinforcement for academic vocabulary.

2.1.9.2.3 Step 3: Silent Independent Reading. Researchers instructed participants to continue reading from the page where the slower reader stopped, silently and independently. The researcher set the timer for the same duration as step one and participants read until the timer went off. Researchers collected data in the same manner as during step one. Once the interval concluded, participants underlined the last word they read. The researcher recorded the last page each participant read. Then participants were instructed to move to the final intervention step.

2.1.9.2.4 Step 4: Comprehensive Drawing Task. The researcher instructed the participants to individually choose a paragraph to draw from the pages they read independently. Participants read at different reading rates, so participants could only select a paragraph within the page range the slowest reader completed. The researcher informed the participants from what
the page range they could select the passage (Refer to Table 2 for researcher script). Participants independently selected a paragraph and informed the researcher what paragraph they selected. Each participant in the pair selected a passage and drew a representation of the passage that the other participant was to use to find the correct passage. Then participants visually represented the paragraph in a drawing on the researcher provided worksheet (Appendix C). The drawing was to be a direct representation of the what the paragraph described. Participants could take as much time as they needed to draw and reference their paragraph. Once each participant completed their drawing, the researcher separately confirmed the paragraph each drawing was from, and then participants swapped papers. The researcher instructed participants to find the paragraph that their partner’s picture represented (Refer to Table 2 for researcher script). Participants recorded their selection of the page number and the paragraph on their worksheet. Once both participants completed the drawing task, the researcher and the participants confirmed the accuracy of their partner’s response.

If both participants correctly identified the paragraph their partner’s drawing represented, they moved up four spaces on the gameboard, two for each participant’s answer. If only one participant answered correctly, the dyad moved up two spaces on the gameboard and completed a correction procedure. The correction procedure required the participant who incorrectly identified the associated paragraph to draw their own interpretation of the paragraph their partner draw. Once the drawing was completed, the partner checked to ensure all parts of the paragraph were included in the new drawing. The correction procedure ended after the participant corrected their drawing. In Bly (2019), criterion for increasing reading intervals was determined by the comprehensive drawing task. This study used the number of intervals engaged in reading behavior during steps one and three as the criterion for increasing reading intervals.
Participants exchanged the points they earned during the intervention for backup reinforcers (Refer to Appendix E for trade-in menu). Both participants had to agree on the decision. The researcher recorded the total number of remaining points for the dyad on a data sheet to transfer to the next intervention session.

If both participants read for 80% or more of the intervals for both independent reading blocks, researchers increased the time reading in steps one and three by two minutes for the next intervention session. If both participants read for less than 80% of the intervals for one or both reading sessions, researchers conducted the next intervention session using the same reading intervals. Once participants met criterion three times, researchers conducted post-intervention probes. Refer to Figure 1 for an outline of the peer-collaborative intervention procedure.
**Figure 1**

*Peer-Collaborative Intervention Procedure Flow Chart*

1. **CR+ probes (STEM and Narrative)**
2. Paired into dyads
3. Four-step peer collaboration intervention
4. Meet criterion?
   - **YES**
     - Increase intervals by 2 minutes for 3 total interval increases
     - CR+ probes
     - Meet criterion?
       - **YES**
         - CR+ probes (STEM and Narrative)
       - **NO**
         - Re-enter intervention with 2 min increase for a second intervention phase
   - **NO**
     - Re-enter intervention at the same time interval
2.1.9.3 Post Intervention Probes

Conditioned reinforcement for reading narrative probes were conducted in the same manner as during pre-intervention probes. If the dyad demonstrated 80% of intervals engaging in reading behavior of narrative texts, the researchers stopped the intervention. If the dyad did not emit 80% of intervals engaging in reading, the dyad was placed back in the intervention with a 2 min increase in their reading duration for Steps 1 and 3. The dyad completed the entire intervention again until they demonstrated establishment of conditioned reinforcement for narrative texts by meeting 80% criterion. There was never an occasion where one member of the dyad met criterion while the other did not. Once the conditioned reinforcement for narrative texts was established, researchers conducted probes on conditioned reinforcement for STEM texts. Researchers ran six post probes (three with narrative texts and three with STEM texts). Three weeks later, researchers ran probes with narrative texts to measure the strength of stimulus control (i.e., maintenance) for conditioned reinforcement of narrative texts.

2.1.9.4 Interobserver Agreement

Researchers collected IOA on 36 of 116 intervention independent reading periods, or 31% of the sessions. The total agreement was 94% with a range of 87% - 100%. There were 58 intervention sessions when accounting for both reading sessions across all intervention sessions for both participants in the dyad.

2.2 Results

Figure 2 displays the number of whole intervals participants actively engaged in reading both narrative (black bars) and STEM (white bars) during baseline, post-intervention, and maintenance sessions. Criterion during reading probes was set at 80% of a 15 min reading period, or 144 intervals of the total 180 intervals. Figure 1 also displays the cumulative seconds
participants engaged in reading during each intervention session. Each intervention session includes two reading opportunities, so each data point is the combined seconds read during both opportunities combined.
Figure 2

Conditioned Reinforcement for Reading Narrative Text Probes

Note. Reinforcement value for narrative texts dramatically increased after completion of the peer collaborative intervention. Reinforcement value for STEM texts remained at similar levels to baseline, post-intervention.
Participants A and B, in Dyad 1, demonstrated moderate levels of intervals reading narrative texts during pre-intervention probes. Participant A read for a mean of 124 intervals of 180, with a range of 110-153. Participant B read for a mean of 113 intervals of 180, with a range of 92-146. Participant A demonstrated lower levels of intervals reading STEM texts, with a mean of 72 intervals of 180, ranging from 38 – 115. Participant B demonstrated moderate levels of reading STEM texts, with a mean of 105 intervals of 180, with a range of 56-143. Dyad 1 completed two intervention sessions to meet criterion for the 2 min intervention phase, three intervention sessions to meet criterion for the 4 min intervention phase, and one session for the 6 min intervention phase. Both participants in Dyad 1 did not demonstrate increased reading time for narrative or STEM texts, both probe responses falling within the mean for the pre-intervention probes. After re-entering intervention, Dyad 1 completed two intervention sessions to meet criterion for the 8 min intervention phase, two intervention sessions to meet criterion for the 10 min intervention phase, and one session for the 12 min intervention phase. Both participants A and B demonstrated an increased level change in reading narrative texts. Participant A read narrative texts for a mean of 172 intervals of 180, with a range of 169-175. Participant B read narrative texts for a mean of 159 intervals of 180, with a range of 153-167. Both participants in Dyad 1 demonstrated similar levels of responding of reading STEM texts to pre-intervention probes. Participant A demonstrated similar lower levels of reading STEM texts, with a mean of 72 intervals of 180, ranging from 65-88. Participant B demonstrated similarly moderate levels of reading STEM texts, with a mean of 110 intervals of 180, with a range of 89-113. Both participants demonstrated continued high levels of responding for maintenance narrative reading probes.
Participants C and D, in Dyad 2 demonstrated low levels of intervals reading narrative texts during pre-intervention probes. Participant C read for a mean of 52 intervals of 180, with a range of 15-94. Participant D demonstrated variable responding when reading narrative texts with a mean of 89 intervals of 180 and a range of 9-156. Participant C demonstrated variable low levels of responding reading STEM texts, with a mean of 47 intervals of 180, ranging from 3-103. Participant D demonstrated moderate levels of reading STEM texts, with a mean of 92 intervals of 180, with a range of 41-124. Dyad 2 completed one intervention session to meet criterion for the 2 min intervention phase, four intervention sessions to meet criterion for the 4 min intervention phase, and one session for the 6 min intervention phase. Participant C demonstrated a slight increase in the numbers of intervals read during the first pre-intervention probe, 118 of 180 sessions, but did not meet criterion to demonstrate the presence of conditioned reinforcement for reading narrative texts. Participant C did not demonstrate increased responding for reading STEM texts. Participant D did not demonstrate increased reading time for narrative or STEM texts, both probe responses falling within the mean for the pre-intervention probes. After re-entering intervention, Dyad 2 completed two intervention sessions to meet criterion for the 8 min intervention phase, one intervention sessions to meet criterion for the 10 min intervention phase, and one session for the 12 min intervention phase. Both participants C and D demonstrated an increased level change in reading narrative texts. Participant C read narrative texts for a mean of 150 intervals of 180, with a range of 136-163. Participant D read narrative texts for a mean of 161 intervals of 180, with a range of 147-171. Both participants in Dyad 2 demonstrated similar levels of responding of reading STEM texts to pre-intervention probes. Participant C demonstrated similar lower levels of reading STEM texts, with a mean of 47 intervals of 180, ranging from 16-84. Participant D demonstrated similarly moderate levels of
reading STEM texts, with a mean of 92 intervals of 180, with a range of 67-111. Both participants demonstrated continued high levels of responding for maintenance narrative reading probes. Participant C demonstrated slightly lower responding on the second narrative probe, but remained at an overall higher level than pre-intervention probes.

Participants E and F, in Dyad 3 demonstrated highly variable, moderate levels of intervals reading narrative texts during pre-intervention probes. Participant E read for a mean of 86 intervals of 180, with a range of 19-142. Participant F read for a mean of 95 intervals of 180, with a range of 39-148. Participant E demonstrated variable low levels of responding reading STEM texts, with a mean of 56 intervals of 180, ranging from 5-126. She demonstrated high responding on the first two probe sessions, with a sharp level decrease for the remaining probes. Participant F demonstrated variable, low levels of reading STEM texts, with a mean of 61 intervals of 180, with a range of 16-111. Dyad 3 completed two intervention sessions to meet criterion for the 2 min intervention phase, four intervention sessions to meet criterion for the 4 min intervention phase, and two sessions for the 6 min intervention phase. Participants E and F demonstrated an increased level change in reading narrative texts. Participant E read narrative texts for a mean of 154 intervals of 180, with a range of 138-158. Participant F read narrative texts for a mean of 147 intervals of 180, with a range of 143-155. Both participants decreased the variability of responding during narrative post-probe interventions. Participants in Dyad 3 demonstrated similar levels of responding of reading STEM texts to pre-intervention probes. Participant E demonstrated similar lower levels of reading STEM texts, with a mean of 64 intervals of 180, ranging from 47-85. Participant F demonstrated slightly higher levels of reading STEM texts, with a mean of 87 intervals of 180, with a range of 76-100. Despite the higher level of responding, the responding during each STEM post-intervention probe fell within the range of
STEM pre-intervention probes. Given time constraints, Dyad 3 did not receive maintenance probes.

Overall, all participants post-intervention probes demonstrated increased reinforcement value for reading narrative texts after the implementation of the peer collaborative intervention. All participants demonstrated decreased variability in responding when reading narrative texts from pre-to post-intervention probes. As reinforcement value for narrative texts increased, the reinforcement value for STEM texts remained similar to pre-intervention levels across all participants.
Note. Researchers took the average of the last three probe sessions for pre- and post-intervention probes. The reinforcement value for narrative texts increased across all participants after receiving the peer-collaborative intervention. Reinforcement value for narratives texts remained at similar levels, or decreased levels, when compared to baseline, post-intervention for most participants.
Figure 3 displays the average reinforcement value of narrative and STEM texts during pre- and post-intervention probe sessions. Researchers took the average of the last three pre- and post-intervention sessions respectively to represent average responding. The black bars represent narrative text responding and white bars represent STEM text responding. All participants demonstrated increased average reinforcement value for reading narrative texts. The change in average reinforcement value for STEM texts demonstrated minimal effects. Participant A demonstrated an average of 115 intervals of reading for narrative texts during pre-intervention probes and 171 intervals during post-intervention probes. They demonstrated an average of 80 intervals of reading for STEM texts during pre-intervention probes and 73 intervals during post-intervention probes. Participant B demonstrated an average of 115 intervals of reading for narrative texts during pre-intervention probes and 160 intervals during post-intervention probes. They demonstrated an average of 84 intervals of reading for STEM texts during pre-intervention probes and 110 intervals during post-intervention probes. Participant C demonstrated an average of 32 intervals of reading for narrative texts during pre-intervention probes and 150 intervals during post-intervention probes. They demonstrated an average of 11 intervals of reading for STEM texts during pre-intervention probes and 47 intervals during post-intervention probes. Participant D demonstrated an average of 104 intervals of reading for narrative texts during pre-intervention probes and 162 intervals during post-intervention probes. They demonstrated an average of 66 intervals of reading for STEM texts during pre-intervention probes and 92 intervals during post-intervention probes. Participant E demonstrated an average of 90 intervals of reading for narrative texts during pre-intervention probes and 154 intervals during post-intervention probes. They demonstrated an average of 34 intervals of reading for STEM texts during pre-intervention probes and 65 intervals during post-intervention probes. Participant F
demonstrated an average of 101 intervals of reading for narrative texts during pre-intervention probes and 148 intervals during post-intervention probes. They demonstrated an average of 70 intervals of reading for STEM texts during pre-intervention probes and 87 intervals during post-intervention probes.

Five of the six participants demonstrated slight increased responding on STEM reinforcement value probes, but the level of responding remained similar. The last participant’s reinforcement value for STEM texts decreased, remaining at a similar level to pre-intervention probe responding. Overall, the peer-collaborative intervention procedure resulted in increased reinforcement value for narrative texts but did not transfer to STEM texts.
2.3 Discussion

Two primary findings can be extrapolated from this study. First, researchers successfully replicated the results of Gentilini and Greer (2021) findings that a peer-collaborative reading intervention increases the conditioned reinforcement for reading narrative texts for elementary students with and without disabilities. Second, implementation of the peer-collaborative reading intervention increased the reinforcement value for narrative texts but did not reliably transfer to STEM texts. Previous literature on reinforcement value for reading found that increasing the reinforcement value for reading narrative texts resulted in increased academic gains, measured through reading comprehension and vocabulary (Gentilini & Greer, 2020, 2021). Gentilini and Greer (2020, 2021) demonstrated that both passage comprehension and vocabulary increases after the reinforcement value of reading narrative fiction is established. We argue that the increased duration of reading is dependent on content becoming the reinforcing property of reading.

The procedures for this study were based off the interventions of prior research on conditioned reinforcement for reading content (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). Gentilini and Greer’s (2020) study examined the reinforcement value for reading narrative texts with second graders. They measured the reinforcement value over a 10 min period and used a teacher and peer collaborative intervention to increase reinforcement value for narrative texts. Researchers decided to measure reinforcement value for reading literature texts over a 15 min period, as Gentilini and Greer (2021) measured it over 10 min with second graders and Bly (2019) measured it over 20 min with fourth graders. In a second study, Gentilini and Greer (2021) compared the effects of conditioning narrative texts with peer-to-peer collaboration or teacher-to-peer collaboration. The effects determined that, for second graders,
using a teacher-to-peer collaboration procedure resulted in stronger increases in reinforcement value for narrative texts. We were unclear whether a peer-to-peer or teacher-to-peer would be more effective for third graders. Our results demonstrate even stronger increases in reinforcement value for narrative texts than Gentilini and Greers (2021) study, indicating our peer-to-peer collaborative intervention for third graders was both appropriate and effective.

The purpose of this study was to determine whether reinforcement value was content dependent. Researchers conditioned narrative texts and measured whether the effects transferred to STEM texts. Given that participants attended the third grade, we used a peer-to-peer collaborative procedure and measured the reinforcement value for reading narrative texts over a 15 min period. Researchers decided to use a peer-to-peer procedure because developmentally, participants were beginning to prefer peers over adults, making peers a stronger reinforcer. They decided on a 15 min period as previous literature used 10 min period for second graders and a 20 min period for fourth graders. The 15 min period fell directly in between both time intervals.

We used the same procedure as Gentilini and Greer (2020) but made slight changes to the procedure. Participants in Gentilini and Greer’s (2020) study met criterion when both participants accurately responding to the comprehensive drawing task. In this study, we changed the criterion measurement. Participants met criterion when they read for 80% of both silent independent reading session during the peer collaboration intervention session consistent with Cumiskey-Moore (2017) and Bly (2019). Researchers decided this measurement was a more appropriate criterion and was a measure of the fidelity of the intervention for this study. Future research should test for which of the criteria is more effective according to characteristics of individual participants.
The pairing procedure used to increase conditioned reinforcement for reading content has taken different forms in previous studies, depending on participant’s ages. In Gentilini and Greer’s (2020) study, they determined that teacher-to-peer collaboration was more effective at conditioning narrative texts than peer-to-peer collaboration for second graders. In Bly’s (2019) unpublished dissertation, she determined that using independent reading sessions within the intervention was more effective at conditioning narrative texts than shared reading, although the peer procedure was effective just less so. However, the peer procedure was more teacher friendly. The current intervention used a peer-to-peer procedure and embedded silent reading components within the collaborative peer intervention consistent with Bly’s findings. The collaborative components within the study were the second and fourth step of the intervention. During the crossword task, participants read the words and definitions aloud and determined which words aligned with each definition and fit within the puzzle. Collaboration and accurate responding were reinforced by allowing participants to move up the contingency game board. We argue that peer interaction functioned as a tactic to condition text by pairing peer interaction, an arguable existing reinforcing activity, with engaging in reading content. In the final step, participants drew a scene from the text and their partner identified the exact sentence the picture represented. If participants responded correctly, they moved up the contingency game board. This task required participants to draw a picture that their partner could correctly identify. We believe this collaboration also acted as a stimulus-stimulus pairing. The peer-yoked contingency game board may also have acted as a conditioning tactic. Future research should isolate the contingency game board from the collaborative peer procedure to determine which tactic produces stronger conditioning effects. Note that Bly did not use the game board and her procedure was successful with her fourth graders. Our findings that the lack of effects on
reinforcement value of STEM texts, as a result of establishing reinforcement value for narrative texts, suggests future research should focus on increasing the reinforcement value of STEM subject matter in our culture if we are to increase our nations performance in science and mathematics measures.

The findings in this study replicated and extended the current research on the reinforcement value of reading. While the reinforcement value for narrative texts did not transfer to STEM texts with participants like those we studied, the inverse relation is unclear. There were a few limitations in the study. We did not take maintenance data of STEM texts. Additionally, we conducted fewer post-intervention probes than pre-intervention probes. While the variability decreased during post-intervention probes for narrative texts, the results would be stronger across five probes rather than three. Future research should test whether increasing the reinforcement value for reading STEM texts would result in increased reinforcement value for reading narrative texts. Researchers should measure maintenance for both content types after one type of content was successfully conditioned. There are no studies testing the relation between increased reinforcement value for STEM texts and the effects on academic achievement. Future research should increase the reinforcement value for reading STEM texts and test the effects on academic achievement for reading. The literature should continue to focus on methodology to increase the reinforcement value for reading, finding efficient and effective intervention that can be implemented within typical classrooms. The literature has shown that reinforcement value is an important component in effective reading instruction.
Chapter 3: Does Increasing the Reinforcement Value for STEM Texts Result in Increased Reinforcement Value for Narrative Texts?

Reading is an essential skill that is required to become an independent learner and member of society. The United States has demonstrated low reading performance at a national level, with less than 40% of all 4th, 8th, and 12th graders meeting basic proficiency measures on standardized tests (US Department of Education). Globally, the United States ranks 13th out of 78th studied countries on reading achievement, falling well below the highest performing country China on reading measures (Organisation for Economic Co-operation and Development, 2018). On mathematical measures, the United States performed much poorer in comparison with reading. Out of 79 sampled countries, the United States ranked 39th on mathematical achievement. On science measures, the United States ranked 18th out of 79 sampled countries, below China, Japan, Korea, Germany, and the United Kingdom (Organisation for Economic Co-operation and Development, 2018). Accurate reading of STEM texts is a fundamental skill within learning math and science skills.

Research in the literacy field address conditioned reinforcement for reading under a different name – reading engagement or motivation. A widely accepted view of reading theory is the Simple View of Reading (SVR) (Gough & Tunmer, 1986; Hoover & Gough, 1990). SVR posits that reading comprehension is the product of quick and fluent decoding and linguistic comprehension. When using SVR as a theoretical background to prescribe interventions, it guides practitioners to only implement interventions targeting the two components that comprise SVR. This theory does not include reading engagement or motivation within its scope, denying practitioners of many effective interventions. Another more recent theoretical perspective paints a more robust picture of reading – the Active View of Reading (AVR) (Duke & Cartwright,
AVR posits that there are four broad categories that comprise the process of reading: (a) self-regulation, (b) word recognition, (c) bridging processes (print concepts, fluency, vocabulary, and morphology), and (d) language comprehension (Duke & Cartwright, 2021). Self-regulation includes the motivation and engagement of a reader as well as the use of taught strategies while reading. Theoretically, motivation must be present for readers to engage in the other three categories of reading. This is not just rooted in the theoretical. A 2023 study found that all the components of AVR impact reading comprehension, but reading motivation is particularly important for students demonstrating reading difficulties (Burns et al., 2023). There are many literacy-based studies that focus on reading motivation, but most studies focus on increasing reading motivation with narrative (literature) texts (Lee et al., 2021). Literacy-based interventions designed to increase reading engagement usually involve increasing the individual’s perception of reading, increasing their perception of themselves as a reader, and increasing social motivation through peer collaborative activities (Rosenzweig et al., 2018).

Behavior analytic research is rooted in behavior analytic principles that explain the environmental contingencies that lead to behavioral change. One such principle is respondent conditioning – repeated pairings that create an overall reinforcing value associated with reading. These pairings are often done through peer collaboration (Bly, 2019; Cumiskey-Moore, 2017; Gentilini & Greer, 2020, 2021). Research has been conducted on increasing the reinforcement value of observing and selecting books leading to increased textually responding to sight words (Tsai, 2006). Other previous research has determined that conditioning narrative texts, through a peer-collaborative intervention, results in increased academic achievement scoresz (Bly, 2019; Cumiskey-Moore, 2017; Gentilini & Greer, 2020, 2021). The current study builds off behavior
analytic research, focusing on increasing the conditioned reinforcement of STEM texts and observing the effects on conditioned reinforcement for narrative texts.

This study sought to answer the following questions:

1. Will the stimulus-stimulus pairing procedure used to increase reinforcement value for STEM texts prove to be effective at increasing the reinforcement value for narrative texts?

2. Will conditioning STEM texts lead to academic gains comparable with the effects of conditioning narrative texts as demonstrated in Bly (2019), Cumiskey-Moore (2017) and Gentilini and Greer (2020, 2021)?

3.1 Method

3.1.1 Participants

Ten third graders, between the ages 8 years, 1 months and 9 years participated in the study (see Table 3 for participant information). The study was conducted in a Title-1, public elementary school outside of a major metropolitan area. Participants were selected from a general education classroom that used the Comprehensive Application of Behavior Analysis to Schooling (CABAS®) and Accelerated Independent Learner model of education (Greer, Keohane, & Healy, 2002). The classroom participants received individualized instruction and research-based tactics derived from the science of behavior analysis to accelerate learning and measure all responses to instruction. One participant qualified for an Individualized Education Program under the eligibility of specific learning disability (see Table 3 for participant information). Two participants were female, and eight participants were male. All participants were selected for this study because they demonstrated low levels of reinforcement value for STEM texts.
Baseline reading achievement varied. Four of the ten participants were below grade-level on the *i-Ready K-12 Adaptive Reading Diagnostic Assessment* (Curriculum Associates, 2017). Four of the ten participants performed on grade level and two of the ten participants performed above grade level on the *i-Ready K-12 Adaptive Reading Diagnostic Assessment* (Curriculum Associates, 2017). Four of the ten participants demonstrated below grade level responding on *i-Ready* diagnostic subtests in vocabulary, literature comprehension, and informational comprehension subtests. Four of the ten participants demonstrated below grade level performance on the *Developmental Reading Assessment* (DRA) (Pearson Education, 2006) (see Table 1).

Participants were separated into two groups – one group of participants that demonstrated lower levels of conditioned reinforcement for narrative and STEM texts (Group 1) and one group of participants that demonstrated higher levels of conditioned reinforcement for narrative texts but demonstrated low conditioned reinforcement for STEM texts (Group 2). Group 1 had six participants and Group 2 had four participants.

**Table 3**

*Description of Participants*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>ELL</th>
<th>Diagnosis</th>
<th><em>i-Ready</em> Literature Text subtest score</th>
<th><em>i-Ready</em> Informational Text subtest score</th>
<th><em>i-Ready</em> Vocabulary subtest score</th>
<th>DRA Level</th>
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</table>

*Note.* ELL refers to English Language Learner status. Y means they receive services as English Language Learners. Early 3 is considered on grade level. Grade 1 or 2 means the participant is the associated number of years behind grade level. Mid 3 equates to performing as a third grader who completed half of their third-grade year. Late 3 equates to performing as a third grader who finished most of their third-grade year. Grade 4 means the participant is one year above grade level.

### 3.1.2 Setting

The study was run in a third-grade classroom at a Title-1, publicly funded elementary school outside of a major metropolitan area. The classroom was a CABAS AIL classroom that employed behavior analytic principles to schooling (Greer, 1998). Different components of the study were run at different areas of the classroom. During conditioned reinforcement probes participants sat at a U-shaped table within the classroom in pairs. Researchers instructed the rest of the class to complete a reading or writing task at their individual desks while researchers filmed probes. Researchers recorded a 15 min reading session using the camera function on an iPhone placed roughly 1 m away from the participants on a tripod.
Researchers ran the four-step peer collaboration intervention at a 0.9 x 1.2 m table in a room adjacent to the classroom. No other students were present during the conditioning procedure. Participants sat next to each other and across from the researcher.

3.1.3 Materials and Equipment

The materials and equipment were largely the same. All texts used during the collaborative conditioning procedure were STEM texts pulled from Reading A-Z. To accommodate participant reading levels, researchers selected STEM books that had multiple versions of varying DRA levels. Texts used during intervention sessions were within two DRA levels of the participants’ independent reading level.

To measure reading achievement, we used the Passage Comprehension and Reading Vocabulary subtests from the Woodcock-Johnson IV Tests of Achievement, a psychoeducational assessment used to assess areas of academic achievement for reading, writing, and mathematics (WJ-IV, Schrank et al., 2014). Researchers used Form A of the WJ-IV to measure pre-intervention responding. Form B was used post-intervention. The content assessed on the WJ-IV only involves narrative texts.

3.1.4 Dependent Variable

Researchers measured two dependent variables: 1) reinforcement value for reading narrative texts and 2) reinforcement value for reading STEM texts. These variables were measured in the same manner as Experiment 1. Researchers added one additional dependent variable - reading academic achievement.

3.1.5 Measurement

The measurement system for all probe and intervention sessions measuring the reinforcement value for narrative and STEM texts were the same as Experiment 1.
3.1.5.1 Woodcock-Johnson IV Tests of Achievement Subtests

Two subtests were used to measure reading academic achievement – Passage Comprehension and Reading Vocabulary. Passage comprehension measures one’s reading comprehension. Participants are provided one or more sentences where a single word is missing. Participants vocally provide the missing word to the examiner. Reading vocabulary has two subparts - synonyms and antonyms. Participants read a single word and provide corresponding synonym or antonym. Subtests were administered and scored as per the guidelines in the administration manual (Schrank et al., 2014).

3.1.6 Interobserver Agreement and Treatment Fidelity

3.1.6.1 Interobserver Agreement

Researchers collected interobserver agreement (IOA) by having a second observer record data simultaneously and independently of the researcher using the videos recorded during probe sessions. Observer agreement is when two novel observers gathered the same data on the same interval, while observer disagreement is defined as when observers demonstrated no agreement on the same interval. Researchers calculated interobserver agreement using interval-by-interval IOA, by adding the total intervals agreement with the same observer agreements divided by the total number of intervals of agreement and disagreement. Researchers collected IOA for 40 of 172 pre-intervention probes, 23% of the sessions. The total agreement was 95% with a range of 87%-100%. For 23 of 100 post-intervention probes, 23% of the sessions, researchers collected IOA. The total agreement was 94% with a range of 85%-100%. For 6 of 20 maintenance probes, 30% of the sessions, researchers collected IOA. The total agreement was 97% with a range of 93%-99%.
3.1.6.2 Treatment Fidelity

Researchers created a checklist of a script of the intervention steps in the study. The checklist was used while conducting the intervention steps, during intervention sessions, in the current study in situ. The checklist included a script and was used for every session (see Table 4). Researchers collected treatment fidelity by assigning a second, independent observer to observe intervention sessions in situ. The independent observer completed the checklist as the researcher implemented the intervention. If the researcher implemented the component according to the checklist, the observer recorded a plus (+). If the researcher did not follow the script, missed a component on the checklist, or incorrectly implemented a component, the observer recorded a minus (-). Researchers calculated the percentage of correctly followed treatment steps by dividing the total number of correctly implemented steps by the total number of steps, multiplied by 100%. Treatment fidelity was collected for 12 of 44 intervention sessions, or 27% of sessions. The total fidelity was 100% across all sessions. Refer to Table 2 for treatment fidelity checklist.

Table 4

Researcher Script and Treatment Fidelity Checklist

<table>
<thead>
<tr>
<th>Researcher Script</th>
<th>Researcher Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Here are the books you will use today. You will also use these pages to complete some activities”</td>
<td>Place the pictureless STEM books indirectly in front of participants. Give one book to each participant. Provide crossword and drawing task papers to participants. Instruct participants to set and start timers to read silently and independently for the average time both participants spent reading during probe sessions. Take 5-second whole interval recording data for active reading behavior. Reading behavior is defined as eyes moving back and forth</td>
</tr>
<tr>
<td>“Set your timer for _____ minutes. During this time, you will read silently. You will be reading all by yourself during. Ready set, start your timers”</td>
<td>Silent reading</td>
</tr>
</tbody>
</table>
“Turn off your timer. Pick up your pencil and underline the last word you read.”
“You are going to work together to solve some crosswords puzzles. Read the definitions on your page and match them with a word in your word bank. You must agree on the same answers. You will move up the game board for each correct response on the crossword.”
“Check your answers against the answer key. If you got the answer correct, move your character up the game board. If not, read the correct definition and word to your partner.”
“Time to silently read again. Look at the page number your partner stopped reading at. Start reading from the lower page number. Flip now to the same page. Set your timer for ______ minutes. During this time, you will read silently all by yourself. Ready set, start your timers.”
Silent reading

“Stop reading. Underline the last word you read. Look at where your partner ended. Circle the last word your partner read in your book. Look back at the pages that you and your partner BOTH read. Select a scene that you will draw. Your goal is to draw the scene with enough detail that your partner can guess the scene. You will move up the game board if you both guess correctly!”
“Now that we are done with the drawing, trade papers with your partner. Look at the drawing and find the exact sentences that describe the picture. Look between pages ______ to ______. Once you find the sentences, write them on the lines provided.”
“Trade papers. Put a plus (+) if your partner wrote the sentences you used to draw your picture. Put a minus (-) if your partner wrote across the page from top to bottom for the entirety of the 5-second interval. Stop reading. Underline the word they stopped reading on. Instruct participants to underline the word they stopped reading on. Instruct students to complete the crossword puzzle.

Instruct students to correct their crosswords using the answer key. Record data on accuracy of completion of crossword puzzle. Ensure participants move up the game board. Instruct participants to set and start timers to read silently and independently for the same number of minutes as the first silent reading block. Instruct participants to start reading where the slower reader ended.

Take 5-second whole interval recording data for active reading behavior. Active reading behavior is defined as eyes moving back and forth across the page from top to bottom for the entirety of the 5-second interval. Instruct participants to select a scene to draw from the pages both participants read. Look at the participant with the slower reading rate and select from the pages they completed reading.

Instruct participants to close their books, trade papers, and write the paragraph or sentences of the scene their partner drew.

Instruct participants to trade back their papers and congratulate their partners. Record data on accuracy of drawing task.
sentences you didn’t use to draw your picture. Give your papers back when you are done.”

If correctly identified the scene:

- *Say to the partner that selected the sentences*: “Nice job selecting the correct sentences.”
- *Say to the partner that drew the picture*: “Nice job drawing a detailed picture that helped your partner find the right sentences.”

If incorrectly identified the scene:

- *Say to the partner that selected the sentences*: “Your partner is going to redraw the picture or add more details so that you can try to select the correct sentences.”
- *Say to the partner that drew the picture*: “Look at the sentences your partner wrote down. They don’t match your picture. Make changes to your current picture or draw a new picture so your partner will select the right sentences to match your picture.”
- “You did not move up the game board. You still have the opportunity to trade in. Select what you would like.”

If the participants both identify the correct scene, they move up the game board and can select a reinforcer at or below their position on the game board.

If one or both participants identified the incorrect scene, the participants who drew the picture must redraw the picture or add detail to the drawing until the partner guesses the correct scene. They do not move up the game board.

Repeat this correction procedure until the partner selects the correct sentences.

Increase the next intervention silent reading time by 2 minutes for both silent reading tasks IF the participants BOTH read for 80% of BOTH silent reading tasks.

After 3 increases in time, conduct a 15 min, 5 s whole interval probe for STEM texts.

### 3.1.7 Independent Variable

Researchers conditioned STEM texts using a four-step peer collaboration procedure. This procedure included four components: (a) independent reading period, (b) crossword task, (c) second independent reading period, and (d) comprehensive drawing task. Both steps involving reading were independent and silent. The collaborative portion of the procedure occurred during
steps two and four where completion of the steps required collaboration between both participants. These collaborative steps acted as the pairing interactions that conditioned STEM texts.

Researchers recorded the number of intervals participants engaged in reading during independent reading periods using the same measurement system used throughout the probe sessions. Criterion for each intervention session was reading 80% of each independent reading period. Participants met criterion when they engaged in reading behavior for 80% of both independent reading periods for the intervention session. If participants met criterion, researchers increased their reading time by 2 min for the next intervention session. Researchers measured accurate responding to the crossword puzzle task if the word from the text’s glossary that matched the corresponding definition was correctly placed within the puzzle. Researchers measured correct responding on comprehensive drawing tasks if one participant identified the exact scene, or exact sentence, from the book portrayed in their partner’s hand-drawn picture. Refer to Figure 4 for an outline of the peer-collaborative intervention procedure.
Figure 4

Peer-Collaborative Intervention Procedure Flow Chart

[Diagram showing flow chart with steps and decision points]

CR+ probes (STEM and Narrative)
Paired into dyads
Four-step peer collaboration intervention
Meet criterion?

YES
Increase intervals by 2 minutes for 3 total interval increases
CR+ probes
Meet criterion?

NO
Re-enter intervention at the same time interval

Re-enter intervention with 2 min increase for a second intervention phase
3.1.8 Procedure

3.1.8.1 Pre-Intervention Probes

The procedure was conducted in the same manner as Experiment 1. Researchers conducted subtests 4 and 17 of the WJIV to measure academic achievement.

3.1.8.2 Intervention: Conditioned Reinforcement via Peer Collaboration

The procedure was conducted in the same manner as Experiment 1 with one slight change. Researchers conditioned STEM texts using the four-step peer collaboration procedure rather than narrative texts.

3.1.8.3 Post-Intervention Probes

The procedure was conducted in the same manner as Experiment 1 with one change to the criterion conditions. Researchers measured the reinforcement value of reading STEM texts until participants met criterion. Then researchers conducted post-probes for narrative and STEM texts to determine the reinforcement value for each reading each content. We measured five post-intervention probes for each content type to ensure stable responding.

3.1.8.4 Interobserver Agreement

Researchers collected IOA on 24 of 88 intervention independent reading periods, or 27% of the sessions. The total agreement was 98% with a range of 96% - 100%. There were 44 intervention sessions when accounting for both reading sessions across all intervention sessions for both participants in the dyad.

3.1.9 Experimental Design

The experimental design is the same as in Experiment 1.

3.2 Results
3.2.1 Conditioned Reinforcement for Reading

Figures 5 and 6 display the number of whole intervals participants actively engaged in reading both narrative (white bars) and STEM (black bars) during baseline, post-intervention, and maintenance sessions. Criterion during reading probes was set at 80% of a 15 min reading period, or 144 intervals of the total 180 intervals. The figures also display the cumulative seconds participants engaged in reading during each intervention session. Each intervention session includes two reading opportunities, so each data point is the total seconds read during both opportunities combined. All dyads read for different times depending on their pre-intervention performance. Refer to Table 5 for intervention reading times for each participant.

Table 5

Minutes Read During Intervention by Dyad

<table>
<thead>
<tr>
<th>Dyad</th>
<th>Participants within Dyad</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
<th>Phase 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G and H</td>
<td>1 min</td>
<td>3 min</td>
<td>5 min</td>
<td>7 min</td>
<td>9 min</td>
<td>11 min</td>
</tr>
<tr>
<td>2</td>
<td>I and J</td>
<td>2 min</td>
<td>4 min</td>
<td>6 min</td>
<td>8 min</td>
<td>10 min</td>
<td>12 min</td>
</tr>
<tr>
<td>3</td>
<td>K and L</td>
<td>5 min</td>
<td>7 min</td>
<td>9 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>M and N</td>
<td>1 min 30 s</td>
<td>3 min 30 s</td>
<td>5 min 30 s</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>O and P</td>
<td>7 min</td>
<td>9 min</td>
<td>11 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Participants G and H, in Dyad 1, demonstrated variable low levels of intervals reading narrative texts during pre-intervention probes. Participant G read for a mean of 54 intervals of 180, with a range of 5-121. Participant H read for a mean of 93 intervals of 180, with a range of...
Participant G demonstrated low levels of intervals reading STEM texts, with a mean of 30 intervals of 180, ranging from 0-84. Participant H demonstrated low levels of reading STEM texts, with a mean of 29 intervals of 180, with a range of 1-98. Both participants demonstrated high variability of total sessions read for both narrative and STEM texts. Dyad 1 completed one intervention session to meet criterion for the 1 min reading intervention phase, two intervention sessions to meet criterion for the 3 min intervention phase, and one session for the 5 min intervention phase. Both participants in Dyad 1 did not demonstrate increased reading time for narrative or STEM texts, although there was an increase in overall level of responding. After re-entering intervention, Dyad 1 completed one intervention session to meet criterion for the 7 min, 9 min, and 11 min intervention phases. Both participants G and H demonstrated an overall slight increased level change in reading narrative texts, with less variability across probe sessions. Participant G read narrative texts for a mean of 98 intervals of 180, with a range of 75-131. Participant H read narrative texts for a mean of 104 intervals of 180, with a range of 76-128. Dyad 1 demonstrated an overall level increase in the number of intervals reading STEM texts, but still demonstrated moderate variability across post-intervention probes. Participant F demonstrated similar higher levels of reading STEM texts from pre-intervention probes, with a mean of 131 intervals of 180, ranging from 75-160. While Participant G demonstrates some variability, he met criterion levels of responding on three of the five post-intervention probes, while all pre-intervention probes fell far below criterion level. Participant H demonstrated moderate levels of reading STEM texts, with a mean of 107 intervals of 180, with a range of 19-164. His responding was overall much higher than pre-intervention probes, but he continues to demonstrate variability. There were two post-intervention probes sessions that met criterion out of the five total sessions, while
responding across all pre-intervention probes fell well below criterion level. Both participants demonstrated continued higher than pre-intervention levels of responding for maintenance narrative reading probes. Participant G’s first narrative maintenance probe was much higher than any previous post-intervention probe. Responding on his second probe fell within the range of other post-intervention probes. Participant H’s first narrative maintenance probe was slightly elevated in comparison to post-intervention probes, while his second probe fell within the range of post-intervention probes. Both participants demonstrated continued high levels of responding reading STEM texts during maintenance probes. Participant G’s responding on STEM maintenance probes was slightly lower compared to post-intervention responding but maintained a higher level of responding when compared to pre-intervention responding. Participant H’s responding on STEM maintenance text remained at a similar level to post-intervention responding.

Participants I and J, in Dyad 2, demonstrated variable low levels of intervals reading narrative texts during pre-intervention probes. Participant I read for a mean of 80 intervals of 180, with a range of 0-133. Participant J read for a mean of 61 intervals of 180, with a range of 0-131. Participant I demonstrated low levels of intervals reading STEM texts, with a mean of 47 intervals of 180, ranging from 18-88. Participant J demonstrated low levels of reading STEM texts, with a mean of 29 intervals of 180, with a range of 1-72. Both participants demonstrated highly variable responding for reading both narrative and STEM texts. Dyad 2 completed one intervention session to meet criterion for the 2 min, 4 min, and 6 min intervention phases. Participant I demonstrated increased responding in her first post-intervention session, one point shy of meeting criterion. Participant J increased his overall level of responding, but also did not meet criterion. Researchers decided to place participants back into intervention. After re-entering
intervention, Dyad 2 completed one intervention session to meet criterion for the 8 min, 10 min, and 12 min intervention phases. Responding on post-intervention probes varied across participants. Both participants demonstrated minimal changes in number of intervals reading narrative texts between pre- and post-intervention probes. Participant I read narrative texts for a mean of 84 intervals of 180, with a range of 39-146. Participant J read narrative texts for a mean of 47 intervals of 180, with a range of 18-88. Participant I demonstrated slightly lower overall levels between pre-and post-intervention probes. Both participants continued to demonstrate high levels of variability. In post-intervention STEM probes, both participants demonstrated an increased level change, but demonstrated low responding in a single probe session. They continued to demonstrate variability but at an overall higher level of responding. Participant I read STEM texts for a mean of 128 intervals of 180, ranging from 87-158. Participant J demonstrated moderate levels of reading STEM texts, with a mean of 105 intervals of 180, with a range of 44-152. His responding was overall much higher than pre-intervention probes, but he continues to demonstrate variability. Participant I demonstrated similar levels of responding on narrative reading maintenance probes to post-intervention probes. Participant J’s first narrative maintenance probe was higher than any previous post-intervention probe. His responding fell into the range of his pre-intervention responding, maintaining the same level of responding throughout pre- and post-intervention probe sessions. Responding on his second probe fell within the range of other post-intervention probes. Participant I demonstrated continued high levels of responding reading STEM texts during maintenance probes. Participant J’s responding on STEM maintenance probes fell to pre-intervention levels.

Participants K and L, in Dyad 3, demonstrated highly variable low levels of intervals reading narrative texts during pre-intervention probes. Participant K read for a mean of 72
intervals of 180, with a range of 0-178. Participant L read for a mean of 95 intervals of 180, with a range of 40-156. Both participants demonstrated variable low levels of responding on STEM pre-intervention probes. Participant K demonstrated low levels of intervals reading STEM texts, with a mean of 63 intervals of 180, ranging from 5-112. Participant L demonstrated low levels of reading STEM texts, with a mean of 83 intervals of 180, with a range of 57-125. Both participants demonstrated highly variable responding for reading both narrative and STEM texts.

Dyad 3 completed one intervention session to meet criterion for the 5 min, 7 min, and 9 min intervention phases. Responding on post-intervention probes varied across participants. Participant K read narrative texts for a mean of 41 intervals of 180, with a range of 10-56. His overall responding decreased from pre-intervention probes, continuing to demonstrate high levels of variability. Participant L read narrative texts for a mean of 138 intervals of 180, with a range of 77-164. Her responding on narrative post-intervention probes remained at a higher level but demonstrated low responding on a single probe. Her responding fell in the range of pre-intervention responding with less variability. In post-intervention STEM probes, both participants demonstrated an increased level change, with less overall variability. Participant K read STEM texts for a mean of 145 intervals of 180, ranging from 90-130. Participant 112-167. Participant L demonstrated moderate levels of reading STEM texts, with a mean of 118 intervals of 180, with a range of 90-130. While three data points fell within the range of pre-intervention responding, her responding was slightly higher with less variability. Participant K’s responding on narrative maintenance probes was much higher than any previous post-intervention probe. They did fall into the range of pre-intervention responding, demonstrating high variability across all pre- and post-intervention probes. Participant L demonstrated similar levels of responding on narrative reading maintenance probes to post-intervention probes. Participant K’s first STEM
maintenance demonstrated similar responding to post-intervention probes. Responding on his second probe decreased below post-intervention levels, falling into pre-intervention ranges. Participant L demonstrated continued high levels of responding on STEM reading maintenance probes. Her first STEM maintenance probe was the highest responding on any STEM probe. Her second probe dropped slightly but remained in the post-intervention range.

Participants M and N in Dyad 4 demonstrated variable moderate levels of reading narrative texts during pre-intervention probes. Participant M read for a mean of 116 intervals of 180, with a range of 12-178. He met criterion levels of responding on four of the seven pre-intervention probes. His responding on the final two pre-intervention probes dropped dramatically. Participant N read for a mean of 140 intervals of 180, with a range of 4-173. He met criterion levels of responding on six of the seven pre-intervention probes. His responding on the sixth pre-intervention probe was substantially lower than all other pre-intervention probes. Both participants responding on STEM pre-intervention probes were at a lower level than narrative responding. Their responding was at an overall moderate level with high variability. Participant M read for a mean of 75 intervals of 180, with a range of 20-166. He met criterion levels of responding on two of the seven pre-intervention probes. Participant N read for a mean of 102 intervals of 180, with a range of 40-166. He met criterion levels of responding on one of the seven pre-intervention probes. Dyad 4 completed one intervention session to meet criterion for the 1 min 30 s, 3 min 30 s, and 5 min 30 s intervention phases. Responding on post-intervention probes varied across participants. Participant M’s overall narrative responding decreased from pre-intervention levels, with a mean of 78 intervals of 180, ranging between 21-134. He did not meet criterion on any narrative post-intervention probes, continuing to demonstrate high levels of variability. Participant N demonstrated similar, slightly lower, levels
of responding on narrative post-intervention probes with a mean of 127 intervals of 180, ranging between of 69-154. He met criterion on two of five post-intervention narrative probes. He demonstrated dramatically lower levels of responding on the third post-intervention probe. In post-intervention STEM probes, both participants demonstrated an increased level change, with less overall variability. Participant M read STEM texts for a mean of 147 intervals of 180, ranging from 111-172. He met criterion levels of responding on four of the five post-intervention probes. Participant N read STEM texts for a mean of 152 intervals of 180, ranging from 100-179. He met criterion levels of responding on four of the five post-intervention probes. Participant M’s responding on narrative maintenance probes increased to a higher level than any post-intervention probes. They did fall into the range of pre-intervention responding, demonstrating high variability across all pre- and post-intervention probes. Participant N’s responding on the first narrative maintenance probes was much higher than any previous post-intervention probe. He continued to maintain a high level of responding on the second narrative maintenance probe. Both participants responding on STEM maintenance probes were similar to post-intervention responding.

Participants O and P in Dyad 5 demonstrated high levels of reading narrative texts during pre-intervention probes. Participant O read for a mean of 147 intervals of 180, with a range of 119-174. He met criterion levels of responding on seven of the nine pre-intervention probes. Participant P read for a mean of 162 intervals of 180, with a range of 135-179. He met criterion levels of responding on eight of the nine pre-intervention probes. Both participants responding on STEM pre-intervention probes were at a slightly lower level than narrative responding. Participant P demonstrated more variable responding than Participant O. Participant O read for a mean of 134 intervals of 180, with a range of 77-157. He met criterion levels of responding on
four of the nine pre-intervention probes. Participant P read for a mean of 117 intervals of 180, with a range of 62-156. He met criterion levels of responding on three of the seven pre-intervention probes. Dyad 5 completed one intervention session to meet criterion for the 7 min, 9 min, and 11 min intervention phases. Responding on post-intervention probes increased across both narrative and STEM texts. On narrative post-intervention probes, Participant O read for a mean of 156 intervals of 180, ranging between 131-179. He met criterion levels of responding on four of the five pre-intervention probes, demonstrating less variability in comparison with pre-intervention probes. Participant P demonstrated similar levels of responding on narrative post-intervention probes with a mean of 172 intervals of 180, ranging between of 161-180. He met criterion on all post-intervention narrative probes. His overall range of responding decreased, demonstrating decreased variability from pre-intervention probes. In post-intervention STEM probes, both participants demonstrated an increased level change, with less overall variability. Participant O read STEM texts for a mean of 163 intervals of 180, ranging from 158-170. He met criterion levels of responding on all post-intervention probes. Participant P read STEM texts for a mean of 163 intervals of 180, ranging from 158-180. He met criterion levels of responding on all post-intervention probes. His overall range of responding decreased, demonstrating decreased variability from pre-intervention probes. Both participants maintained post-intervention levels of responding on narrative and STEM maintenance probes.
Figure 5

Conditioned Reinforcement for Reading STEM Text Probes – Group 1

Note. White bars now represent reinforcement value of narrative texts. Black bars now represent reinforcement value of STEM texts. Reinforcement value for STEM texts increased after completion of the peer collaborative intervention. Reinforcement value for narratives texts remained at similar levels to baseline, post-intervention.
Conditioned Reinforcement for Reading STEM Text Probes – Group 2

Note. White bars now represent reinforcement value of narrative texts. Black bars now represent reinforcement value of STEM texts. Reinforcement value for STEM texts increased after completion of the peer collaborative intervention. Reinforcement value for narratives texts remained at similar levels, or decreased levels, when compared to baseline, post-intervention.
Figure 7 displays the average reinforcement value of narrative and STEM texts during pre- and post-intervention probe sessions. Researchers took the average of the last three pre- and post-intervention sessions respectively to represent average responding. The white bars represent narrative text responding and black bars represent STEM text responding. Participant F demonstrated an average of 35 intervals of reading for narrative texts during pre-intervention probes and 94 intervals during post-intervention probes. They demonstrated an average of 29 intervals of reading for STEM texts during pre-intervention probes and 119 intervals during post-intervention probes. Participant G demonstrated an average of 59 intervals of reading for narrative texts during pre-intervention probes and 109 intervals during post-intervention probes. They demonstrated an average of 14 intervals of reading for STEM texts during pre-intervention probes and 125 intervals during post-intervention probes. Participant H demonstrated an average of 72 intervals of reading for narrative texts during pre-intervention probes and 99 intervals during post-intervention probes. They demonstrated an average of 67 intervals of reading for STEM texts during pre-intervention probes and 112 intervals during post-intervention probes. Participant I demonstrated an average of 21 intervals of reading for narrative texts during pre-intervention probes and 24 intervals during post-intervention probes. They demonstrated an average of 16 intervals of reading for STEM texts during pre-intervention probes and 90 intervals during post-intervention probes. Participant J demonstrated an average of 72 intervals of reading for narrative texts during pre-intervention probes and 28 intervals during post-intervention probes. They demonstrated an average of 55 intervals of reading for STEM texts during pre-intervention probes and 134 intervals during post-intervention probes. Participant K demonstrated an average of 87 intervals of reading for narrative texts during pre-intervention probes and 128 intervals during post-intervention probes. They demonstrated an average of 74
intervals of reading for STEM texts during pre-intervention probes and 110 intervals during post-intervention probes. Participant L demonstrated an average of 51 intervals of reading for narrative texts during pre-intervention probes and 74 intervals during post-intervention probes. They demonstrated an average of 46 intervals of reading for STEM texts during pre-intervention probes and 147 intervals during post-intervention probes. Participant M demonstrated an average of 112 intervals of reading for narrative texts during pre-intervention probes and 122 intervals during post-intervention probes. They demonstrated an average of 82 intervals of reading for STEM texts during pre-intervention probes and 148 intervals during post-intervention probes. Participant N demonstrated an average of 149 intervals of reading for narrative texts during pre-intervention probes and 166 intervals during post-intervention probes. They demonstrated an average of 132 intervals of reading for STEM texts during pre-intervention probes and 163 intervals during post-intervention probes. Participant O demonstrated an average of 155 intervals of reading for narrative texts during pre-intervention probes and 173 intervals during post-intervention probes. They demonstrated an average of 105 intervals of reading for STEM texts during pre-intervention probes and 165 intervals during post-intervention probes.

All participants demonstrated increased average reinforcement value for reading STEM texts. The change in average reinforcement value for narrative texts demonstrated minimal effects but did increase for some participants. Eight of the 10 participants demonstrated slight increased responding on narrative reinforcement value probes but did not demonstrate increased overall level changes. One participant’s reinforcement value for narrative texts decreased and another remained the same. Overall, the peer-collaborative intervention procedure resulted in increased reinforcement value for STEM texts but did not transfer to narrative texts.
Figure 7

*Average Pre- and Post- Intervention Conditioned Reinforcement Responding*

*Note.* White bars now represent reinforcement value of narrative texts. Black bars now represent reinforcement value of STEM texts. Reinforcement value for STEM texts increased after completion of the peer collaborative intervention. Reinforcement value for narratives texts remained at similar levels, or decreased levels, when compared to baseline, post-intervention.
3.2.2 Reading Achievement

Figures 8 and 9 display participant responding on the Woodcock-Johnson IV subtests 4 (passage comprehension) and 17a/b (antonyms and synonyms). On the passage comprehension subtest, six of the ten participants demonstrated increased responding. Six participants scored within or above the range of scores expected for typical third grade students. Four participants scored below the range of expected scores. Of those four participants, one was very close to the expected range. Three participants demonstrated low responding and remained low on the post-test assessments, falling well below the expected grade level range of responding. On the synonym and antonym subtests seven students increased their overall scores. Seven of the ten scored within or above the range of scores expected for typical third grade students. Three participants scored below the range of expected scores, with one of the three participants growing to just below the expected range. The other two participants remained well below the expected range of responding for third grade students on pre and post-tests.
Figure 8

Woodcock-Johnson-IV Passage Comprehension Scores

Note. The blue bar depicts the expected range of scores for the typical third grade student. Diamonds represent pre-test scores and circles represent posttest scores. Scores are reported using grade-level equivalency.
Figure 9

Woodcock-Johnson-IV Synonym and Antonym Scores

*Note.* The blue bar depicts the expected range of scores for the typical third grade student. Diamonds represent pre-test scores and circles represent posttest scores. Scores are reported using grade-level equivalency.
3.3 Discussion

There were two conclusions drawn from this study: 1). Researchers successfully conditioned STEM texts using the peer-collaborative intervention, 2). Increasing the reinforcement value for STEM texts does not transfer to narrative texts. There is not a bi-directional relationship between the reinforcement value for STEM and narrative content. Reading academic achievement was variable across participants.

This study was built off the prior study to determine whether increased reinforcement value for STEM texts could transfer to narrative texts. The reinforcement value does not transfer, which indicates that conditioning procedures should be applied to each genre separately. These findings have implications for educational instruction. There are two educational implications: (1) Participants should undergo conditioning procedures for narrative and STEM texts separately and (2) Practitioners should intersperse narrative and STEM texts within instruction as a form of multiple exemplar instruction (MEI) Research has demonstrated that MEI has successfully induced Bi-Directional Naming (BiN) (Greer et al., 2005). We posit that implementing an MEI procedure with text content, adding peer or teacher pairings, might assist with the conditioning of each content type.

The intervention procedure included both stimulus-stimulus pairing, operant conditioning, and conditioned reinforcement for denial. Participants experienced multiple pairings with STEM content through peer-interactions during crossword tasks and comprehensive drawing tasks. They also received pairing when moving up the gameboard for accurate responding on these tasks. When participants did not meet criterion for reading during the intervention block, they experienced a form of operant conditioning. Usually, participants asked how they did during the reading block, as they quickly discovered their responding on
reading tasks led to increases in time. The increase of time acted as a reinforcer for reading behavior, as students met the predetermined goal. Repeating the time interval acted as a punishing effect for non-reading behavior since students understood their reading performance did not meet criterion level. Participants were excited about the total time they read and were overheard discussing it with their peer partner. The remainder of the class observed the dyad receiving reinforcement and gaining access to rewards through the peer-yoked contingency. Children that were not part of the current dyad manded to be a part of the intervention just to gain access to the reward. Denying access to the intervention temporarily, due to design constraints, increased the reinforcement value of the intervention itself. Participants even began to strategize on ways to gain the most points, offering advice to the newest dyad in the study. These moments of conversation and strategy acted as another pairing interaction for participants with the intervention. There were many forms of conditioning the intervention and STEM content happening throughout this study. It is unclear how strong of a role each type of conditioning plays, or whether they are all essential as a treatment package. Future studies should attempt to isolate these variables to determine the role the strength of each factor in increasing the reinforcement value of STEM content.
Chapter 4: General Discussion

4.1 Major Findings

4.1.1 Conditioned Reinforcement for Narrative and STEM content

The findings of Experiment 1 and Experiment 2 are consistent with the findings of previous research on conditioned reinforcement for reading content (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). The peer-collaborative procedure is an effective intervention at increasing the reinforcement value for both narrative and STEM texts. Previous research only found that the peer-collaborative intervention was effective for narrative texts, but we determined that it is effective for STEM texts as well (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). The underlying question of our studies was to determine whether increasing the reinforcement value of one reading content, using the peer-collaborative intervention procedure, would also increase the reinforcement value of the other reading content. Our findings indicate that there is no bidirectionality between reinforcement value for content types. Experiment 1 found that increasing the reinforcement value for narrative texts did not result in increases of reinforcement value of STEM texts. Experiment 2 found two things: 1). the peer-collaborative intervention procedure successfully conditioned STEM texts and 2). increasing the reinforcement value for STEM texts did not result in an increase in the reinforcement value of narrative texts. All participants, regardless of IEP eligibility or reading level demonstrated an increase in reinforcement value for the targeted content type, measured by the number of whole 5 s intervals participants looked at books. Given the lack of bidirectionality between reinforcement value of content type demonstrates that researchers are indeed conditioning the content, not just the behavior of looking at a book.
4.1.2 Academic Achievement

Previous research determined that increasing the reinforcement value of narrative texts results in increased academic achievement, measured by the Woodcock Johnson-IV (WJIV) (Cumiskey-Moore, 2017; Bly, 2019; Gentilini & Greer, 2020, 2021). Our study demonstrated that increasing the reinforcement value for STEM texts also results in increased academic achievement, but not for all participants. Seven of the 10 participants demonstrated increases on responding on Passage Comprehension and Reading Vocabulary (tacting synonym and antonyms) subtests of the WJIV. There were three participants (G, H, and J) that, while increasing their overall reinforcement value for STEM texts, did not demonstrate gains on the WJIV assessment. The three participants that did not demonstrate academic gains demonstrated pre-intervention responding far below the average third grader. After intervention, their responding did not change drastically. Researchers believe that these participants were missing prerequisite cusps to fully benefit from the study. Participants G, H, and J read below grade level and are still acquiring the cusps related to learning to read. While overall they observed books for longer, they were lacking cusps to access the content. The participants that did make gains on the WJIV subtests demonstrated the following verbal behavior developmental cusps: 1) conditioned seeing, 2) conditioned reinforcement for observing books, 3) and were under the stimulus control for textually responding to phonemes, particularly with multisyllabic words.

All participants completed the I-Ready K-12 Adaptive Diagnostic at the start of the school year (Curriculum Associates, LLC, 2017). They completed their mid-year diagnostic shortly after the conclusion of the study. Researchers noticed that six of the ten participants scores increased substantially on their informational comprehension subtests. The four participants that did not increase their test scores already demonstrated grade level responding.
Participant G increased from a Grade 1 to Grade 2 on the informational comprehension subtest. Participant H, I, and J increased from a Grade 1 to an Early 3rd grade level on the informational comprehension subtest. Participant K increased from an Early 3rd grade level to a late 3rd grade level on the informational comprehension subtest. Participant P increased from a Grade 2 to an early 3rd grade level on the informational comprehension subtest. Researchers did not control for confounding variables for the *I-Ready K-12 Adaptive Diagnostic*, but believed this informal data is another indicator of the academic gains children can make when the reinforcement value for content is established.

Overall, there was no clear bidirectionality between reinforcement value for content type. When the reinforcement value of narrative texts increased there were no changes in the overall reinforcement value of STEM texts did not increase. When the reinforcement value of STEM texts increased there were some changes in narrative texts. The overall change in responding was not dramatic and did not represent a level change, but there were some changes in narrative responding. If practitioners were to choose which direction to condition texts, we would recommend conditioning STEM texts first. There is some evidence that conditioning STEM texts would have some effect on narrative reinforcement value as opposed to the inverse, where no change is present.

### 4.2 Limitations and Future Research

There were limitations across the two experiments. Experiment 1 was conducted in the aftermath of the COVID-19 pandemic. Participants engaged in the peer-collaborative intervention following social distancing requirements. The social distancing protocols were antithetical to a peer-pairing procedure. There were also prolonged absences because of quarantine procedures. Design-wise, researchers did not take maintenance data on both content
types. Researchers were not able to make claims on the maintenance effects of reinforcement value for STEM texts in Experiment 1. Researchers also did not collect the same amount of post-intervention probes as pre-intervention probes. There was some decline in responding towards later pre-intervention probes. Given that researchers conducted fewer post-intervention probes in Experiment 1, it is unclear whether responding also would have declined post-intervention.

These design limitations were corrected in Experiment 2. A limitation of Experiment 2 was there were time gaps between the first five pre-intervention probes and the last two pre-intervention probes. Researchers required time to watch and record data for all 50 pre-intervention probes across the 10 participants. Researchers decided to implement the last two pre-intervention probes, for a total of seven pre-intervention probes, to ensure an accurate reflection of participant responding just before entering intervention. Additionally, researchers ran maintenance probes five weeks after the completion of the intervention. In Experiment 1 researchers ran maintenance probes three weeks after the completion of the intervention. In Experiment 2, researchers faced prolonged participant absence and school breaks that coordinated with participant intervention completion.

Both experiments found that there is no bidirectionality between the reinforcement value of contents. Researchers should determine whether rotating content type using multiple exemplar instruction could lead to increased reinforcement value for both content types. Additionally, researchers should determine whether there are instructional practices and curricular arrangements that can be embedded within daily instruction that can increase reinforcement value for reading content. There were many forms of conditioning that occurred throughout the intervention process. Future research should determine the role that the peer-yoked contingency versus the peer-pairing interactions play on increasing reinforcement value for content.
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Appendix A

Whole-Interval Data Collection Sheet

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Appendix B

Crossword Tasks

**Across**
3. people who work in one or more areas of science
5. a ball-shaped map of the world
6. to keep from harm or danger

**Down**
1. able or likely to cause harm
2. the main sections of land on Earth, including Africa, South America, Asia, Europe, North America, Australia, and Antarctica
4. turned into ice as a result of very cold temperatures
Appendix C

Comprehension Drawing Task - Student Sheet

Comprehension Drawing Task

Student Sheet

Book Title: __________________________
Chapter: __________________________
Pages Read: _______________________

Draw a picture of your favorite scene. Please look back in the text of specific details. Be sure to include as many details as possible.

Friend’s Response:
Describe what scene this is from the book:

Is this correct or incorrect? _____________
Appendix D

Peer-Yoked Contingency Game Board
Appendix E

Intervention Trade-In Menu

Trade-In Menu

5 spots or less: 100 points

6 spots: 5 minutes of free time together or 150 points

8 spots: 7 minutes of free time together or 5 minutes of extra recess together

10 spots: 10 minutes of free time together or 7 minutes of extra recess together

12 spots: 15 minutes of free time together or 10 minutes of extra recess together

14 spots: 5 minutes of extra break for the whole class or 12 minutes of free time together

16 spots: 7 minutes of extra break for the whole class or 15 minutes of free time together

18 spots: 7 minutes of extra recess for the whole class or 5 minutes of Promethean drawing time

20 spots: 10 minutes of extra recess for the whole class or 7 minutes of Promethean drawing time

25 spots or more: lunch with a teacher with two guests or 10 minutes of Promethean drawing time

30 spots or more: lunch with a teacher with four guests or 15 minutes of Promethean drawing time.