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Examining the Effects of a Game-Based Learning Environment on Fifth Graders' Reading Comprehension and Reading Motivation

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A growing body of research suggests that comprehension of expository texts presented digitally is a challenging endeavor, particularly for children. Many reading interventions, both from traditional classroom settings and computer-based contexts, have focused on much needed strategy instruction but have simultaneously neglected a focus on motivation. Alternatively, game-based learning environments (GBLEs) have the potential to simultaneously address both motivation and strategy use. Currently, there are few available GBLEs that target expository text comprehension. For this reason, this study employed a quasi-experimental betweensubjects media comparison design to examine the effects of Missions with Monty, a GBLE supporting metacomprehension for expository science texts, on reading comprehension and motivation. Fifth-grade students (N = 234) engaged with either Missions with Monty or a comparison, computer-based version of the program lacking gamified elements for a period of 6 weeks and were assessed on reading comprehension skills and five dimensions of reading motivation. Results indicated that students in the GBLE condition showed significantly greater improvements in reading comprehension (g = 0.56), intrinsic motivation for reading (g = 0.56) 0.52), and curiosity (g = 1.11) than their comparison-condition peers. Moreover, effects of the intervention on reading motivation were independent of prior reading comprehension for each of the reading motivation dimensions except reading efficacy. These findings support the notion that GBLEs can be an effective tool to foster digital expository text comprehension, particularly for struggling and uninterested readers.

Educational Impact and Implications Statement

Digital expository texts are challenging to comprehend particularly for children. Thus far, interventions have focused mainly on cognitive aspects of text comprehension; engaging readers has not been a focus. The current study adopted a dual-pronged approach presenting an engaging learning environment combined with strategy instruction and showed that game-based learning environments can be suitable tools to foster reading comprehension and reading motivation.

Keywords: game-based learning environments, reading motivation, text comprehension

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Comprehending digital expository texts is a particularly challenging endeavor for children, and interventions to support such comprehension have focused primarily on cognitive strategies while neglecting motivational aspects of reading (Fox & Alexander,

2017). For instance, computer-based learning environments (CBLEs) have emphasized explicit strategy instruction to foster learning outcomes related to text comprehension (e.g., Lee et al., 2021; McNamara et al., 2006; O'Reilly et al., 2004; K. K. Wijekumar et al., 2013, 2017; Xu et al., 2022); however, they typically lack an explicit focus on engagement (McCarthy et al., 2020). In contrast, studies of some successful offline, classroom-based reading comprehension programs have combined strategy instruction with an emphasis on increasing learner motivation resulting in significant effects for reading comprehension, motivation, and strategy use when compared to strategy instruction only or business-as-usual classroom instruction (Guthrie & Klauda, 2014; Guthrie et al., 2000, 2004, 2007, 2013). This dual-pronged approach is important for improving both reading proficiency and motivation to read (e.g., Guthrie et al., 2004; C. E. Snow, 2017) and may be especially crucial in digital environments where students face unique challenges related to attentional demands (Daniel & Woody, 2013). However, the role that motivation plays in teaching comprehension skills in online programs has yet to be thoroughly tested.

Game-based learning environments (GBLEs), if structured appropriately, can offer strategy instruction and practice as well as encourage

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motivation. Although there is no consistently agreed upon definition, digital GBLEs are games with specific learning goals (Plass et al., 2020) and are generally considered to be rule-based, responsive, challenging, cumulative, and include elements to promote engagement (Mayer, 2014). Although prior research has reported mixed findings regarding their motivational appeal compared to traditional forms of instruction (Wouters et al., 2013), this may be due to operationalizing motivation too narrowly, measuring only a singular dimension, which may reflect a limited account of student motivation. Indeed, initial research is promising in that GBLEs focused on promoting self-explanation (Jackson & McNamara, 2013) and morphological awareness (Qiao et al., 2022) have shown positive indicators of student motivation. However, currently lacking from the GBLE literature is a focus on reading comprehension as an outcome measure.

The purpose of the current study was to examine the efficacy of a GBLE when compared to a CBLE, matched for content, to isolate the impact that motivational gaming elements have upon reading comprehension and reading motivation. Given the need to test the extent to which successful practices from offline, classroom-based reading comprehension instruction apply in a digital GBLE, we initiated a media comparison (Mayer, 2019) to isolate the impact of game-based elements designed to increase motivation as students learn. Media comparison studies are essentially studies where the comparison group is exposed to the same learning material as the treatment group but with varying methods of presentation (e.g., tutorials, slideshow presentation, etc.; see Adams et al., 2012). These designs can be especially advantageous because they offer an opportunity to parse out motivating effects, if any, related to the mode of presentation as opposed to the pedagogical content. Furthermore, as noted by Mayer (2019), a media comparison study may be suitable because "the available evidence provides no reason to conclude that games are generally inferior to traditional instruction and some reason to suspect that games can be as effective or more effective than traditional instruction for certain instructional domains and objectives" (p. 544). Therefore, the present study examined the efficacy of a science GBLE, Missions with Monty, to impact fifth graders' metacomprehension skills on expository texts over distributed practice sessions relative to a CBLE carefully matched on content, training, and feedback. This comparison allowed for the isolation of the motivational effects of Missions with Monty and subsequent impact on students' reading comprehension skill and various constructs of reading motivation.

The Role of Reading Motivation in Expository Text Comprehension

The ability to comprehend texts, a prerequisite for academic success, is a complex endeavor. It involves the process of constructing meaning from the text and integrating it with information in the reader's knowledge base (Kintsch & Rawson, 2005; Thiede & de Bruin, 2018). Text comprehension is further complicated by the type of text being read (i.e., narrative vs. expository texts) and the interface on which the text is presented (i.e., digital vs. print). Expository texts aim to deliver a large amount of information in a succinct manner (Alexander, 2019). Because expository texts, like science texts, are typically organized in nontemporal, spatial, and a logical–argumentative structure (Ragnarsdóttir et al., 2002) and often contain difficult technical vocabulary requiring readers to expend substantial effort to decode (Ray & Meyer, 2011), they can be considerably more

challenging to comprehend than narrative texts (Duke & Roberts, 2010; Graesser et al., 2003).

In traditional classroom contexts a primary approach for facilitating reading comprehension in the upper elementary grades has been to employ explicit strategy instruction. This includes a focus on active cognitive strategies, encouragement for students to personalize strategies, metacognitive components designed to teach students when and where to apply strategies, distributed practice over numerous weeks, and a focus on transfer (Pressley & Harris, 1990; Schraw & Gutierrez, 2015). For instance, following this approach with fifth-grade (10-year-old) students, Andreassen and Bråten (2011) found a large increase in strategy use ($\eta_p^2 = .05$) but no effects for reading motivation.

The current study is situated within the theoretical perspective of the concept-oriented reading instruction (CORI) model that is unique in that it places a high degree of emphasis on increasing learner engagement in addition to a focus on strategy instruction as a means to improve literacy outcomes (Guthrie et al., 1996, 2007). The framework views students as having multiple goals for reading and emphasizes real-world science observation, collaborative learning, self-expression, self-direction, strategy instruction, and coherence of literacy experiences. Motivational-engagement supports incorporated in CORI are informed by multiple theoretical perspectives and include autonomy support for intrinsic motivation, emphasis on the importance for valuing reading, success and goal setting for self-efficacy, and collaborative activities for social motivation (Guthrie & Klauda, 2014). The program has shown impressive results, particularly when compared to isolated strategy instruction and traditional classroom instruction. Comparison of third graders in CORI to a strategy instruction group and a traditional instruction group found the CORI students to be higher in reading comprehension, motivation, and reading strategies (Guthrie et al., 2004). Similar findings have been extended to middle school as Guthrie et al. (2013) found significant effects for seventh graders in the CORI program on motivation, engagement, and achievement relative to traditional reading/language arts instruction. Consistent across implementations of CORI are extended opportunities for the integration of motivational-engagement supports in classroom activities, typically lasting at least 6 weeks or longer (Guthrie et al., 2004; Guthrie & Klauda, 2014; Rosenzweig & Wigfield, 2017).

While a rich reading comprehension literature exists in offline environments, attention is increasingly drawn to digital texts that are replacing printed texts as children's preferred interfaces for reading (Eutsler & Trotter, 2020). CBLEs facilitate comprehension of expository texts in multifarious ways, by supporting students to identify text structures (e.g., Meyer et al., 2002), through vocabulary supports (Dalton et al., 2011), or through the explicit training of metacomprehension strategies (McNamara et al., 2006). In some cases CBLEs have been associated with gains in reading comprehension on both standardized and researcher-developed measures of reading comprehension (e.g., K. K. Wijekumar et al., 2013, 2017); however, they focus solely on providing explicit instruction of reading strategies in an interface not considered engaging and hence may lead to feelings of monotony and boredom (Jackson & McNamara, 2017; Kaakinen et al., 2018). The few CBLE studies that have examined the motivational impact of their intervention have not found significant effects in comparison to conventional instruction (e.g., ter Beek et al., 2019) and there appears to be a propensity for students to disengage before reaching mastery (Bell & McNamara, 2007). Moreover, motivation tends to be measured using a single motivational construct (e.g., "choice" in Meyer et al., 2010).

Reading Motivation as a Multidimensional Construct

In line with the CORI perspective (Guthrie et al., 2004) and other scholars (Conradi et al., 2014; Davis et al., 2020), the current study operationalized reading motivation as a multidimensional construct that includes an individual's reasons for reading driven by their attitudes, values, goals, interest, and self-beliefs. Five dimensions were selected from scales developed within the CORI framework (Guthrie et al., 2012; Wigfield et al., 1996) for the current study that included reading value, intrinsic motivation for reading, reading efficacy, curiosity, and extrinsic motivation constructs (i.e., grades, competition, and recognition) for reading (see Table 1). The extant literature includes other dimensions such as achievement goals and social motivation, under the umbrella of reading motivation; however, these constructs have not yet been contextualized to reading for elementary-aged children (e.g., Conradi et al., 2014; Davis et al., 2018). The included dimensions are described further below.

Reading value pertains to the inherent value one affords to the reading task, specifically importance and utility (Guthrie et al., 2012). According to expectancy-value theory (Eccles & Wigfield, 2002) a reader's subjective task value depends upon their expectancy for success and perceived value of the activity. This involves consideration of previous achievement-related experiences, personal importance of performing well on the task, affect, intrinsic value, utility value, and cost. Reading value has been shown to have a negative relationship with boredom for elementary students when reading multiple online texts (Raccanello et al., 2022).

Intrinsic motivation to read refers to an individual's willingness to read because they derive satisfaction and pleasure from the act in and of itself. Self-determination theory (Ryan & Deci, 2020) centers on the encouragement of intrinsic motivation in autonomy supportive learning environments. Results from meta-analyses support the importance of intrinsic motivation for school achievement (Taylor et al., 2014). Qiao et al. (2022) found that a gamified English reading instruction improved intrinsic motivation relative to a nongamified version for eight-grade students.

Reading efficacy refers to readers' evaluations of their competence to accomplish a given reading task (Conradi et al., 2014). Reading efficacy is shaped by one's past experiences, observations of others engaged in

similar reading tasks, social persuasion, and one's physiological reactions (Bandura, 1997). Differential exposure to these sources of selfefficacy can lead to significant variation in the development and rate of change in primary school students (Peura et al., 2021). Reading efficacy has been found to be a predictor of digital reading performance (Chen et al., 2022) and text comprehension (Guthrie et al., 1999).

Curiosity is characterized by information seeking that is independent of external rewards or structure (Gottlieb & Oudeyer, 2018) and translates to repeatedly reading to satisfy one's interests (Wigfield & Guthrie, 1997). Curiosity has overlapping theoretical relationships with interest to the extent that the prior literature has yet to draw clear distinctions between the two concepts. (Murayama, 2022). We operationalized this dimension using the curiosity subscale of the Motivation to Read Questionnaire (Wigfield et al., 1996) that focuses on one's positive orientation towards reading about a particular topic and relates directly to the current study involving numerous different science topics.

Extrinsic motivation for reading is based on possible incentives or consequences associated with reading. Extrinsic motivation to read involves reading to obtain something rather than reading for the activity itself (Wigfield & Guthrie, 1997). In the current study extrinsic motivation to read was operationalized with three subdimensions that included grades, recognition, and competition mirroring theoretical frameworks posited by Davis et al. (2020) and Syal et al. (2023). Within the context of literacy-based GBLEs it is important that extrinsic motivation elements within the game mechanics promote engagement yet do not increase learners' reliance upon extrinsic motivation for reading, something tested in the current study.

Motivation in GBLEs

O'Brien and Toms (2008) have described engagement in serious games as characterized by focused attention, control, interactions with the interface, intrinsic motivation, and feedback. There are a number of attributes that have been included in GBLEs to elicit such engagement with evidence to support their connections to learning. Mayer (2019) emphasizes five such value-added attributes including the use of spoken text, conversational language, pregame information, in-game advice and feedback, and prompts that have players explain or reflect that have been shown to boost learning by at least 0.4 *SD*s across multiple studies. Other attributes that impact learning include the use of a rich narrative that incorporates discovery

Table 1

Description of the Reading Motivation Scale Used in This Study

Construct	Definition	Sample item	Cronbach's a
	Constructs from Motivation to Read Inform	ational Books (Guthrie et al., 2012)	
Reading value	Belief that reading is important, relevant, or useful	Reading information books is more useful than most of my other activities for school	.67
Intrinsic motivation	Intrinsic reasons to read and having a desire to read often	I enjoy reading information books for school	.80
Reading efficacy	Beliefs about his or her capacity to complete school reading tasks	I can explain what I have read in information books to my classmates or friends from school.	.84
	Constructs from the Motivation to Read Q	uestionnaire (Wigfield et al., 1996)	
Curiosity	Desire to read in order to learn more about new topics	I read to learn new information about topics that interest me	.80
Grades	Pursuit of high reading grades in school	I read to improve my grade	.82
Recognition	Pursuit of recognition for success in reading	I am happy when someone recognizes my reading	.81
Competition	Desire to outperform others in reading	I like being the best at reading	.83

and/or mystery (Hamari et al., 2016; Johnson et al., 2017; Wouters & van Oostendorp, 2017), the level of realism favoring the use of cartoon-like representations rather than photorealistic representations (Wouters & van Oostendorp, 2017), and pedagogical agents that provide communication and feedback (Goldberg & Cannon-Bowers, 2015). Some of these attributes have been observed to have considerable effects on students' learning outcomes. For instance, in the review by Wouters and van Oostendorp (2017), a large effect size was observed for cartoon-like representations as opposed to realistic representations. These design choices for GBLEs can aid in engaging learners, likely by triggering learners' situational interest (Rodríguez-Aflecht et al., 2018), which can fuel the information search process thus increasing the depth of information processing. The GBLE used in the current study employed all of the design attributes described above with the exception of the use of spoken text.

Missions With Monty

The GBLE employed in the current study was Missions with Monty, a narrative-centered learning environment (Rowe et al., 2012) that integrates narrative, subject matter, and gameplay, focused on improving fifth graders' science literacy by developing their metacomprehension skills on science expository texts. Gameplay begins by introducing the student to the narrative. The student has been hired by Monty the monitor lizard, a world-famous scientist who established Wildlife University in a remote, fictitious rainforest in the South-Eastern region of Africa. As soon as the player arrives, they find that the university is closed because many of the animals, who are students and professors, have fallen ill. The player also discovers that Monty is missing. Thus, the player is challenged to determine the cause of illness and to locate Monty. To do so, players first engage in a "training camp" to prepare for their missions that essentially functions as a strategy instruction unit related to highlighting, monitoring, and summarizing led by game characters. Players then embark on a set of missions that involve visiting various animal researchers in their natural setting to read up on their "research," which are science expository passages (see Figure 1) related to the topics of ecosystems and the interdependence of organisms.

Motivation to read and comprehend the in-game research passages connects directly to the narrative as players must piece together critical knowledge and understanding at each site in order to develop informed hypotheses to solve the two game problems. After reading each text presented at the various research stations, players are presented with a series of challenges that assess their knowledge, monitor accuracy, and ability to identify main ideas. In addition, periodic challenges occur that test the player's multiple source comprehension across passages. During this process players obtain clues that help them solve the two overarching problems as they proceed through the four units in the game, also referred to as "days." This cyclical process of completing challenges at each research site promotes extended distributed strategy practice within the narrative of the game, scaffolded by characters that function as pedagogical agents, while also providing customized immediate feedback.

As players progress through the game they are encouraged to support their hypotheses with evidence that they gather during their investigation. Evidence constitutes saved highlights, summaries, and images (Figure 2). Students must narrow down their collection of evidence on a detective board before submitting their final hypothesis. After students submit their detective boards, they also attempt to identify the culprit who kidnapped Monty.

The aims and development process of the GBLE used in the current study are akin to the aforementioned CORI program, that is an emphasis on promoting student self-direction while emphasizing both strategy instruction and motivation in goal-directed learning. Thus, the expectation was that the gamified elements and narrative included in Missions with Monty would support students' reading motivation. Reading value is encouraged by placing reading within a purpose driven problem-solving context where comprehension becomes integral for solving the narrative-based problems. Intrinsic motivation for reading is likely to arise from the context, an animal-themed fantasy world wherein the player plays the role of protagonist in helping to save Wildlife University and find Monty. Reading efficacy is potentially facilitated with recurring challenges presented in the game that push players to organize information in increasingly more complex ways (from highlights to summaries to multiple source comprehension and finally narrowing on a detective board) with accompanying

Figure 1

An Expository Text in Missions With Monty With Cici the Civet (Left) and the Comparison Condition (Right)



Note. See the online article for the color version of this figure.

Figure 2

(Left-Right, Clockwise) Missions' Journal Tablet With Summaries, Highlights, and Images Apps



Note. See the online article for the color version of this figure.

feedback. Curiosity would be inspired by first presenting the gamified fantasy world to draw players into reading about science topics as they meet characters and are "recruited" to help solve the in-game dilemmas. As players progress through the game, their curiosity is maintained by meeting and interacting with new characters that assist them in solving the game-based scientific problems. The influence of extrinsic motivation to read is evident in the opportunity to earn badges, points, and advance in levels during the game.

Purpose of the Study

GBLEs that provide explicit instruction to help readers comprehend expository texts in digital settings are few, with the most notable being McNamara and colleagues' interactive strategy training for active reading and thinking-motivation enhancing (iSTART-ME; Jackson et al., 2011). iSTART-ME was shown to be as effective as the CBLE version of the tool (i.e., iSTART), yet more motivating for adolescent learners (Jackson & McNamara, 2013; E. L. Snow et al., 2016). Given the dearth of reading strategy-based GBLEs targeting upper elementary-aged readers there is a need to examine the efficacy of these environments to foster expository text comprehension and motivation during this crucial developmental period for strategic reading (Soto et al., 2019). Therefore, this 6-week study tested the impact of the Missions with Monty GBLE on reading comprehension and reading motivation. A quasi-experimental between-subjects media comparison design (Mayer, 2019) allowed for the examination of the impact of the GBLE on multiple dimensions of reading motivation. Classrooms were randomly assigned to either the GBLE treatment condition or the CBLE comparison condition to examine potential additive effects of game-based design elements included in the GBLE. Both conditions contained identical science content and reading strategy instruction, and students in both conditions received the same practice items; the primary difference being that students in the treatment group engaged in a gamified version of the content, that is, Missions with Monty, that included a rich mysterybased narrative, interactions with pedagogical agents, and audiovisual effects. These goals informed the following research questions:

Research Question 1: What is the impact of playing the GBLE Missions with Monty relative to a matched CBLE on students' reading comprehension performance and reading motivation?

Building off the work within the CORI model from offline classroom-based contexts (Guthrie & Klauda, 2014; Guthrie et al., 2000, 2004, 2007, 2013), this study sought to examine the role that motivation plays on reading comprehension and reading motivation in a GBLE. In order to compare the relative impact of the GBLE and CBLE on reading comprehension two measures were examined, a researcher-designed text comprehension task and a standardized measure of reading comprehension. In line with prior studies that have utilized researcher-designed outcomes (e.g., K. Wijekumar et al., 2013) and standardized reading assessments as outcomes (e.g., K. Wijekumar et al., 2014), significant positive treatment effects were expected for both measures.

Specific to motivation, we expected to find advantages for students in the GBLE condition in similar fashion as in Jackson and McNamara's (2013) study. However, given the limited amount of prior research examining specific dimensions of reading motivation in computer-based environments we did not determine a priori hypotheses for each dimension.

Research Question 2: Does prior reading comprehension moderate treatment effects on self-reported motivation?

In addition to examining the efficacy of Missions with Monty, it was important to ascertain if treatment effects on self-report reading motivation depended on students' prior reading comprehension skill. Developing engaged readers results in important cognitive spinoffs that include motivated readers becoming more proficient readers because they read more, exertion of more cognitive effort on challenging texts, and the use of more reading strategies (Baker et al., 2010; Guthrie et al., 2004; Guthrie & Wigfield, 2000; Lutz et al., 2006; Tarchi, 2017). In turn, readers' increasing competence motivates them to read more and this recursive relationship can exacerbate "Matthew effects" in reading because the skilled become more skilled and the less skilled do not improve (C. E. Snow, 2017; Stanovich, 2009). Therefore, it was important to test the extent to which prior knowledge moderated the relationship between the GBLE experience and motivation. Findings from McBreen and Savage's (2021) systematic review on the impact of motivational reading instruction interventions, which focused not just on reading skill-based components but also on motivation, suggested that students' prior reading skill (i.e., less-skilled struggling readers vs. skilled readers) did not significantly moderate the intervention effects on students' reading motivation. Because existing evidence was not sufficient, the present study explored whether significant moderation effects would be obtained in the context of GBLEs.

Method

Participants

Participants included students from 13 fifth-grade classrooms in four public schools in the Southeast United States. Although the present study adopted a quasi-experimental design, classrooms were randomly assigned to the comparison (N = 83 from five classrooms) or the treatment condition (N = 151 from eight classrooms). Efforts were taken to ensure that both groups had equal sample sizes; however, numbers in the comparison group were reduced due to attrition related to the COVID-19 pandemic. After parental consent was obtained, a final sample of 234 fifth-grade students (boys = 119, girls = 107, other = 3, and prefer not to disclose = 5) with mean age of 10.34 years were recruited. Demographics included students from 67% White, 12% Black or African American, 10% Hispanic or Latin American, 1% Native American/Pacific Islander/Alaskan Native, 4% two or more races, and 2% Asian backgrounds along with 4.3% who preferred not to disclose their backgrounds.

Procedure

The study took place over the course of 9 weeks. During the first week students completed a reading comprehension assessment along with motivation measures contextualized to reading in the online Qualtrics environment. Classrooms were then randomly assigned to either the comparison or the treatment condition. During the 6 weeks that followed all students received a specific intervention. Students in the treatment condition played Missions with Monty, a GBLE described in detail in the following section, whereas students in the comparison condition played a nongamified, CBLE version of Missions with Monty (Figure 1). Students in both groups read the same set of expository texts in the same sequence, received the same reading strategy training, and were provided with the same feedback. The primary difference between the two groups was that the non-GBLE version did not have engaging elements like that in Missions with Monty including the game narrative with overarching problems, interactive pedagogical agents, and elements associated with the aesthetic appeal, such as ambient sounds and visuals. Students in both groups engaged with Missions with Monty for two 45-min sessions a week for 6 weeks. One exception to this was two classrooms in the treatment condition where students engaged with the program daily for 2 weeks during their English language arts and science blocks because their teacher was under quarantine due to the COVID-19 pandemic. In the eighth and ninth weeks, respectively, students completed posttest measures of motivation and reading comprehension.

GBLE Treatment Condition

Students in the treatment condition were first shown a short video introducing them to the narrative of Missions with Monty, including the introduction of the two problems described above. After this short introduction students took part in "training camp," strategy training hosted on a digital platform separate from the GBLE and CBLE programs where explicit instruction on each of the following strategies: highlighting main ideas, selecting a summary that best represents the passage, and metacognitive monitoring on one's knowledge through confidence judgments. Training involved Missions with Monty characters modeling the purpose and use of each of the strategies through videos followed by students having the opportunity to practice each strategy. Students completed this initial training in one 45-min session.

Upon completion of this initial strategy instruction session, students moved directly into the Missions with Monty environment where they visited animal researchers to read science expository passages about their various research topics over the course of 6 weeks. Players were instructed in the narrative that they could gain important information from this "research" in order to determine the cause of the mystery illness. After reading each text, players were required to complete a set of challenges, presented by the animal characters, related to the target reading strategies in a standard order. The animal characters functioned as embodied pedagogical agents (Goldberg & Cannon-Bowers, 2015) as they introduced themselves to students and provided directions and feedback via conversational text to the students. It is important to note that explicit connections were not made to refer the students back to what was learned in the strategy training session.

For each text, students first highlighted main ideas in the text. Next during a summary challenge, students selected one summary from three options that best captured the essence of the text. The three summary options were systematically created and varied in terms of quality by the research team. If students chose the most appropriate summary on their first attempt, feedback indicated this, and they moved to the next challenge. If not, students received another opportunity to select the best option from the two remaining summaries. The knowledge challenge required students to answer questions to check their understanding of the text. Feedback included highlighting the correct answer regardless of the option chosen by the student. The items measured both knowledge and conceptual understanding. Finally, a monitoring challenge required students to provide confidence judgments for their answers from the knowledge challenge on a 0-100 scale. Feedback provided students with their answer choice, confidence estimate, degree of over or underconfidence, and the correct answer. Students were able to gain badges based upon their level of performance in each challenge.

The length of the texts ranged from 250 to 350 words with Flesch-Kincaid levels ranging from 4 to 7. Prior to this study, all passages and assessment items, created by the research team in consultation with participating teachers, were examined and revised based on findings from a validation study with fifth graders (N = 330) from four participating schools.

CBLE Comparison Condition

Students in the CBLE comparison group completed an identical version of the "training camp" led by the Missions with Monty characters as those in the treatment condition. After completing the strategy training they then proceeded to read the same expository texts and complete the same assessments that were presented as challenges in the GBLE. The content and timing of feedback in both conditions were also identical. However, the comparison condition differed in that it did not contain the narrative, pedagogical agent characters, and other engaging elements (audiovisual effects, badges). Instead, the experience was presented on a digital nongame based learning platform in Qualtrics as an in-class language arts and science activity.

Measures

Students in both groups were assessed on the following measures.

Reading Comprehension Outcomes

Standardized Reading Comprehension Measure. The Gray Silent Reading Test (GSRT: Wiederholt & Blalock, 2000) Forms A and B were administered as pretest and posttest measures of reading comprehension, respectively. Each form included a mix of 13 narrative and expository texts, developmentally sequenced, each with five multiple-choice questions for a total of 65 items. The texts were available to the students when answering the multiple-choice questions that consisted of both declarative and inferential items. In accordance with the administration instructions, students began at Passage 3 and continued onwards until they received a score less than or equal to 2 on a specific passage. The assessment ended when a ceiling was determined. If a student received a score less than or equal to 2 on the third passage, they were redirected to the second passage and then the first until a basal score was determined. The GSRT took approximately 15-30 min to complete and was administered online via Qualtrics. The GSRT has shown high reliability for both forms (Form A, $\alpha = .95$ and Form B, $\alpha = .94$, respectively) as reported in Wiederholt and Blalock (2000). Scores ranged from 10 to 62 from the possible 65 items.

Researcher-Designed Passage Comprehension Measures. Two expository texts, previously created by a member of the research team (Hoffmann, 2010) and related to a larger classroom-based intervention (Urban et al., 2023) in alignment with the state's fifth-grade science curriculum, were utilized as a posttest measure of text comprehension (see Appendix A). The texts were standardized according to ease of readability (i.e., Flesch-Kincaid grade level = 5.0-6.0) and length (i.e., 399 and 412 words). The passages included topics unrelated to those in the intervention (i.e., hurricanes and volcanoes) but were similar in length and complexity to passages in the intervention. The passages were reviewed for content and difficulty level by seven fifth-grade teachers and a county-level senior administrator for elementary science (Hoffmann, 2010). Five multiple choice items, measuring declarative knowledge, vocabulary, determining main ideas, and inferences were included with each passage resulting in a total possible score of 10.

Motivation Measures

Reading Motivation. In this study reading motivation was measured using a confluence of reading motivation constructs taken from the Motivation to Read Informational Books (MRIB-S: Guthrie et al., 2012) and the Motivation to Read Questionnaire (MRQ: Wigfield et al., 1996). Table 1 presents detailed information about the constructs used in this study. These measures were administered as pretests and posttests. Responses for the MRIB-S range from 1 (not at all true of me) to 4 (very true of me) and those for the MRQ range 1 (very different from me) to 4 (very like to me). Reading value, intrinsic motivation, and reading efficacy were taken from scales on the MRIB-S. From the MRQ, curiosity and three extrinsic motivation subscales (i.e., grades, competition, and recognition) were used. (see Table 1 for a sample items). The three extrinsic motivation subscales were combined into a factor score for the purpose of analysis. Support for a one-factor solution for extrinsic motivation was obtained through factor analysis; hence, subsequent analysis employed the single-factor score of extrinsic motivation. Cronbach's alpha for these subscales indicated an adequate reliability range from .67 to .84 (see Table 1). Mean scores for these five subscales were used for analysis.

Transparency and Openness Statement

This study was not preregistered. However, the data can be made available by emailing the corresponding author.

Results

This study employed hierarchical linear modeling (HLM: Raudenbush & Bryk, 2002) to examine treatment effects on reading comprehension and reading motivation. Because classrooms were randomly assigned to either the treatment or comparison condition, HLM is appropriate as it considers effects owing to the nested nature of data.

A preliminary analysis was conducted to ascertain the extent of variability at Levels 1 and 2 and whether this variability was sufficient to proceed with analysis (Raudenbush & Bryk, 2002). Performance on the standardized reading comprehension measure and motivation to read were entered as outcomes in the models with time as a predictor to model unconditional change in outcomes. Equations for all models can be found in Appendix B. Table 2 includes descriptive statistics for the sample. Students in treatment classrooms did not differ from those in comparison classes at baseline on reading comprehension using the GSRT (t = -0.15, p = .498). Detailed findings from all of the HLM models that were conducted can be found in Tables S1-S3 in the online supplemental materials for estimates from fixed and random effects from the null model, the intercepts and slopes as outcomes for the reading comprehension and reading motivation outcomes models in Table S2, and the Level 2 moderator variables in Table S3.

Treatment Effects on Reading Comprehension

In order to examine the treatment effects of Missions with Monty on the standardized reading comprehension measure, an intercepts and slopes as outcomes model was conducted with time (i.e., pre– post measures) as a Level 1 predictor and treatment (i.e., comparison vs. experimental) as a Level 2 predictor (see Table 3). Results indicated significant main effects for time ($\gamma_{10} = 5.19$, t = 5.12, p < .001; g =0.52), where reading comprehension scores significantly improved at

	Pretest			Posttest		
Variable	Ν	М	SD	Ν	М	SD
Gray Silent Reading Test						
Treatment	151	27.04	7.61	149	32.23	9.32
Comparison	83	26.84	8.92	83	29.46	7.81
Text comprehension task						
Treatment				149	6.17	1.71
Comparison				83	5.63	1.38
Intrinsic motivation						
Treatment	149	2.41	0.62	149	2.59	0.75
Comparison	83	2.46	0.66	83	1.93	0.50
Reading efficacy						
Treatment	149	2.60	0.66	149	2.73	0.54
Comparison	83	2.88	0.53	83	3.14	0.62
Reading value						
Treatment	149	2.62	0.53	149	2.96	0.70
Comparison	83	2.61	0.51	83	2.95	0.59
Curiosity						
Treatment	149	2.55	0.77	149	3.17	0.60
Comparison	83	3.23	0.29	83	2.31	0.32
Grades						
Treatment	149	2.90	0.59	149	2.97	0.60
Comparison	83	2.90	0.44	83	2.95	0.56
Competition						
Treatment	149	2.35	0.77	149	2.40	0.75
Comparison	83	2.25	0.70	83	2.28	0.72
Recognition						
Treatment	149	2.78	0.76	149	2.83	0.69
Comparison	83	2.51	0.65	83	2.63	0.70

 Table 2

 Descriptive Statistics and Group Comparisons for Major Study Variables

posttest regardless of the condition. Additionally, significant interaction effects were observed ($\gamma_{11} = 5.49$, t = 7.44, p < .001; g = 0.56), indicating significantly higher gains for reading comprehension in the Missions with Monty GBLE condition when compared to the non-GBLE condition.

To evaluate the effect of the treatment condition on performance on the two researcher-designed text comprehension tasks controlling for prior reading skill, a one-way analysis of covariance (ANCOVA) was conducted. HLM was not employed for this analysis given that the text comprehension tasks were administered only as a posttest. Results from this ANCOVA revealed a treatment effect on the researcher-designed comprehension tasks even after controlling for prior reading comprehension skill measured by pretest GSRT, F(1, 231) = 6.65, p = .011, $\eta_p = .03$. Marginal means indicated that students in the GBLE condition (M = 6.18) significantly outperformed those in the comparison group (M = 5.66).

Treatment Effects on Reading Motivation

In order to examine changes in reading motivation as a function of the treatment, an intercepts and slopes as outcomes model was

Table 3 Estimates of Treatment Effects on Reading Comprehension

Estimate	Effect size	Significance	
4.98	-0.52	***	
5.49	0.46	***	
	Estimate 4.98 5.49	Estimate Effect size 4.98 -0.52 5.49 0.46	

*** p < .001.

conducted with time (i.e., pre–post measures) as a Level 1 predictor and condition as a Level 2 predictor for each of the subconstructs of reading motivation (i.e., intrinsic motivation, reading efficacy, reading value, and extrinsic motivation constructs; see Table 4).

Specific to intrinsic motivation, significant main effects for time $(\gamma_{10} = -0.52, t = -6.91, p < .001)$ with an effect size of g =-0.43, where intrinsic motivation decreased at the time of posttest for the sample in general. However, a significant interaction effect was observed ($\gamma_{11} = 0.70$, t = 7.41, p < .001, g = 0.52), where improvements in intrinsic motivation were observed among students in the treatment condition. With respect to reading efficacy, a significant main effect for time was obtained ($\gamma_{10} = 0.40, t = 4.37$, p < .001, g = 0.30), where students reported significantly higher reading efficacy at posttest regardless of the condition to which they belonged. However, no significant interaction effect between students' condition and time on reading efficacy was observed. In the case of reading value, a significant increase from pre to posttest $(\gamma_{10} = 0.34, t = 4.23, p < .001, g = 0.27)$ was found regardless of the group to which students belonged. No significant interaction effects for reading value were observed. With respect to curiosity, there was a significant main effect for time ($\gamma_{10} = -0.92, t = -8.18$, p < .001) with an effect size of g = -0.67, where curiosity decreased at the time of posttest without accounting for students' condition. When treatment was added as a predictor, a significant interaction effect was obtained ($\gamma_{11} = 1.54$, t = 13.60, p < .001, g = 1.11) indicating higher scores among students in the treatment condition relative to the comparison condition. Finally, with respect to extrinsic motivation no significant main effects for time or treatment were observed.

 Table 4

 Estimates of Relevant Effects on Reading Motivation

	Intercepts and slopes as outcomes model			Level 2 moderator models		
Fixed effect	Estimates	Effect size	Significance	Estimates	Effect size	Significance
Intrinsic motivation						
Time	-0.52	-0.43	***			
Time \times Treatment	0.70	0.52	***			
Time \times Treatment \times PreRC				-0.01	-0.12	
Reading efficacy						
Time	0.40	0.30	***			
Time \times Treatment	0.14	0.10				
Time \times Treatment \times PreRC				0.03	0.23	*
Reading value						
Time	0.34	0.27	***			
Time \times Treatment	0.002	0.01				
Time \times Treatment \times PreRC				0.02	0.17	
Curiosity						
Time	-0.92	-0.67	***			
Time \times Treatment	1.54	1.11	***			
Time \times Treatment \times PreRC				0.01	0.11	
Extrinsic motivation						
Time	0.07	0.06				
Time \times Treatment	-0.01	-0.00				
Time \times Treatment \times PreRC				-0.01	-0.12	

Note. PreRC = pretest reading comprehension.

*p < .05. ***p < .001.

Prior Reading Skill Moderating Motivation

A three-way interaction model with time, condition, and prior reading comprehension skill was conducted for each of the five reading motivation constructs to examine whether treatment effects were contingent on students' prior reading comprehension skill (see Table 4). Results from this analysis revealed a significant three-way interaction between time, condition, and prior reading comprehension skill only for reading efficacy ($\gamma_{13} = 0.03$, t = 2.16, p < .05, g = 0.23). This indicates that prior reading comprehension skill significantly moderated the relationship between condition and reading efficacy over time. That is, treatment effects on reading efficacy over time were contingent on students' prior reading comprehension. For the purpose of graphing this significant three-way interaction (see Figure 3), scores at or below 1 *SD* was considered low prior reading

comprehension and scores at or above 1 SD was considered high prior reading comprehension.

Discussion

Prior research in offline reading programs has established that motivation plays a powerful role in the text comprehension process (Guthrie & Klauda, 2014; Guthrie et al., 2000, 2004, 2007, 2013). Yet, less is known about this relationship in online environments, particularly when focusing on the multidimensional nature of motivation. Moreover, there remains a gap in the literature on reading comprehension as an outcome variable with upper-elementary students in such environments. Therefore, the current study examined the impact of a GBLE on reading comprehension and reading motivation for fifth graders when compared to a CBLE, matched for content, in a

Figure 3

Decomposing Moderation Effects for Reading Efficacy for the Comparison (Left) and GBLE (Right) Conditions



Note. GBLE = game-based learning environment; RC = reading comprehension.

media comparison design within a classroom context. A number of important findings emerged that have implications for this field of study. First, although both the CBLE and GBLE conditions showed significant gains on a standardized reading comprehension measure, students who played Missions with Monty significantly outperformed students in the CBLE on both the standardized reading comprehension test (g = 0.56) and researcher-designed text comprehension task ($\eta_p = .03$), highlighting the added benefit of motivational components in such instruction. Indeed, the fact that both study conditions demonstrated significant improvements on the standardized reading comprehension measure reflects the importance of strategy instruction more broadly. Second, the Missions with Monty GBLE supported increases in intrinsic motivation to read and curiosity relative to students in the comparison condition in addition to increases in reading value and reading efficacy found across conditions. Third, of the five reading motivation dimensions students' prior reading comprehension skill was a significant moderator only for reading efficacy, a promising finding supporting the advantage of leveraging GBLEs to potentially support reading value, intrinsic motivation, and curiosity within reading instruction for all students. Finally, study findings highlight the nuances related to the multiple dimensions of reading motivation suggesting a need to examine the unique contributions of these dimensions more fully in future studies. Implications and future directions from these findings are described in more detail below.

Impact of the GBLE on Reading Comprehension

Findings from this study supported our hypothesis that an engaging GBLE would have positive effects on reading comprehension over and above effects found for a CBLE matched for content and reading strategy instruction. From a theoretical standpoint, results support the value-added approach of pairing motivationally supportive elements with strategy instruction in the online learning environment, matching findings from offline environments (Guthrie et al., 2004, 2013). We acknowledge that "one-to-one" comparisons are not possible between the GBLE condition used in the current study with motivation-engagement elements employed in classroom-based CORI designs. Rather, we argue more generally that a structured attempt to enhance motivation in parallel with reading comprehension skills during the learning process aids in the development of comprehension and reading motivation.

With regard to reading comprehension, findings were consistent with those from K. Wijekumar et al. (2014) where significant treatment effects were obtained on both researcher-designed reading comprehension measures and the standardized measure of reading comprehension. However, the present study differed from that of K. Wijekumar et al. (2014) in two ways. The first difference centers on the intervention used wherein the treatment group in Wijekumar et al. (2014) engaged in a CBLE that trained students to identify text structures as a comprehension strategy. In the present study, the treatment group engaged in a GBLE, which had pedagogical content integrated within the framework of the narrative. A second difference between the K. Wijekumar et al. (2014) and the present study was the comparison group. In the former, the comparison group engaged in business-as-usual language arts classroom instruction which did not involve matched content with the treatment group, whereas the comparison group in the present study engaged with matched science content without the game narrative. Moreover, the CBLE condition in the current study engaged in strategy-training and comprehension assessments with immediate feedback, making this a potentially more stringent comparison than that employed by K. Wijekumar et al. (2014). Moderate effect sizes were found in the current 6-week study and small effect sizes in the K. Wijekumar et al. (2014) study that took place over 6 months. In sum, these findings highlight the impact of the GBLE and emphasis placed on motivation combined with concentrated cycles of distributed practice with feedback when teaching reading comprehension and offer promise for other systems to incorporate similar connections between motivation and strategy instruction. Applied implications suggest that teachers can use this or similar GBLEs that offer self-pacing and customized feedback to augment their classroom instruction to support reading comprehension.

Impact of the GBLE on Reading Motivation

With respect to motivation in reading contexts, significant effects consistent with findings from Jackson and McNamara (2013) were found wherein students in the GBLE condition reported higher posttest intrinsic motivation and curiosity than students in the CBLE comparison condition. Reading value and reading efficacy increased across the two conditions while extrinsic motivation did not change significantly in either condition. Our finding that Missions with Monty had a positive impact on reading motivation contradicts Wouters et al. (2013) conclusion that GBLEs offer no more motivational benefits than conventional classroom instruction. Furthermore, unlike Jackson and McNamara's (2013) study, the present study operationalized motivation specific to reading contexts. It is also important to note that most studies included in Wouters et al. (2013) metaanalysis employed motivational measures disconnected from learning contexts.

In the current study it is difficult to decompose elements of Missions with Monty to ascertain which led directly to the differences in motivation that occurred between conditions. Possible indicators include the mystery narrative, the rich audiovisual game world, and the animal-themed pedagogical agents and also the role played by the student as the protagonist tasked to solve the overall game dilemmas. Nonetheless, the overall effect of Missions with Monty on intrinsic motivation for reading and curiosity is encouraging and makes a unique contribution to the existing literature. The gains made across conditions for reading value and reading efficacy are similarly encouraging. Both the CBLE and GBLE offered concentrated and distributed practice opportunities with immediate feedback. Taking advantage of this, students were able to use what they learned to solve game-based problems thus potentially impacting perceptions of reading value and were also able to complete challenging tasks across sessions that led to increased reading efficacy.

Encouragingly, no significant increases were found in the treatment condition for extrinsic motivation to read, indicating that the use of badging, points, and game levels provided for reading performance in the GBLE did not relate to an increased extrinsic motivation to read. This finding, while nondirectional, is an important finding particularly with regard to potential challenges of presenting students with a learning environment that includes numerous opportunities to earn external rewards and recognition. It seems likely that students disassociate between extrinsic rewards and recognition earned for reading performance within the game context with the act of reading outside of game contexts, given their familiarity with game mechanics and exposure with games in daily life. This finding is critical if learners are able to avoid the potentially undermining effects of extrinsic rewards presented in GBLEs while at the same time benefiting from the engaging environment.

Another finding that deserves consideration is the fact that students in the comparison group reported significant decreases in motivation. This outcome can be attributed to the nature of the digital interface used. Although both GBLEs and CBLEs offer numerous practice opportunities, CBLEs can run the risk of becoming redundant, monotonous, and in its extreme form can result in boredom eventually leading to frustration and dread (McCarthy et al., 2020). The very attributes that can make GBLEs engaging, namely a rich narrative with seamless content integration, pedagogical agents with whom students can interact, and other characteristics that can capture students' attention thereby triggering interest (Tobias & Fletcher, 2007), were absent in the comparison condition. As such, perhaps students in the comparison condition experienced monotony, or lack of purpose such as that generated by a compelling narrative, which may have resulted in the observed decrease in reported motivation.

The Moderating Effect of Prior Reading Comprehension Skill

Findings related to the moderating effect of prior reading comprehension skill demonstrate the importance of examining reading motivation as a multidimensional construct. Results of the current study suggest that treatment effects on four of the five reading motivation dimensions (i.e., intrinsic motivation, curiosity, and reading value, and extrinsic motivation) were not moderated by prior reading comprehension skill. This finding has important implications as it suggests that GBLEs, like Missions with Monty, can potentially provide motivational benefits to students regardless of their reading comprehension level. Yet, crucially, treatment effects on reading efficacy over time were significantly moderated by prior reading comprehension. In essence, treatment effects for reading efficacy over time depended on students' prior reading comprehension. Figure 3 provides a snapshot of this interaction and how estimates of treatment effects on reading efficacy over time can be observed for students with low reading comprehension (i.e., less than 1 SD) and those with high reading comprehension (more than 1 SD). Findings from this analysis may have implications for understanding the role GBLEs might play in the bidirectional relationship between reading and motivation, especially since motivated readers are likely to become more competent readers because they engage in more reading practice, are willing to exert cognitive effort on challenging texts, and are likely to use appropriate reading strategies (Guthrie et al., 2004; Guthrie & Wigfield, 2000; Taboada et al., 2009).

Limitations

When evaluating findings for this study, it is important to note some caveats. Although the viewpoint that reading motivation is multidimensional is agreed upon (e.g., Conradi et al., 2014; Davis et al., 2018; Neugebauer & Fujimoto, 2020; Schiefele et al., 2012; Toste et al., 2020; Wigfield & Guthrie, 1997), there continues to be a lack of consensus on what constitutes reading motivation (e.g., Forzani et al., 2020; McBreen & Savage, 2021). However, this multidimensionality poses a problem as there is no consensus on the theoretical frameworks used to operationalize reading motivation and even the number of dimensions that must be included in reading motivation. Jéldrez et al. (2023) note that this lack of consensus makes it challenging to draw comparisons between study findings. We chose five prevalently measured dimensions of reading motivation that could potentially be impacted by playing a GBLE. However, additional motivational constructs (e.g., achievement goals) are important to consider. As such, further research focusing on the development of a guiding theoretical framework of reading motivation is needed.

A second limitation includes issues pertaining to fidelity of the intervention. This study took place at a time when schools and teachers were grappling with after-effects of COVID-19 and, as a result, when students had to quarantine, they completed the intervention at home. Teachers reported back to the researchers on a weekly basis through a short survey about such accommodations. In one case, students in two classes engaged with the intervention daily for 2 weeks during English language arts and science hours totaling 9 hr because their teacher had to quarantine. Nevertheless, this amount of time is consistent with playtime of the rest of the sample.

A third limitation is that due to technical problems trace measures were not used to compare navigation and performance through the CBLE and GBLE. Trace data might contribute important process-oriented information for comparison but also function to triangulate with self-report measures of motivation. For instance, process data may have informed student interactions with the content and also the impact of the pedagogical agents and audiovisual effects on time on task and completion of the text passages and associated text assessments. Finally, collaborative learning is a cornerstone process in the CORI model; however, the current study did not integrate collaborative learning into the programs. This would be a logical next step to examine how collaboration further impacts reading motivation and how potential coregulatory activities may impact learning.

Conclusions and Future Directions

Despite these limitations, findings from the current study are promising in that it demonstrates potential benefits to students' reading comprehension skill and reading motivation. That is, using a dual-pronged approach for explicit reading strategy instruction in the form of a GBLE, can be advantageous to fostering students' reading skill and their motivation. Results from this study also reinforce the argument that GBLEs can indeed be motivating at least in comparison to a traditional CBLE irrespective of students' prior skill. Given that this study utilized the construct of reading motivation as its motivational outcome, further research is needed on how best to conceptualize reading motivation. For instance, from a game design standpoint, further research is needed to ascertain how specific elements in GBLEs presented in these environments contribute directly or indirectly to learning and motivation to comprehend texts (Naumann, 2015). This might involve testing variations of motivational "scaffolds" and their appropriateness across varying contexts, domains, and developmental levels of the learners. Altogether, the findings in the current study are promising for supporting diverse learning needs as schools embrace educational technology to support virtual learning and supplement classroom instruction.

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Appendix A

Example Researcher-Designed Passage Comprehension Task

Hurricanes

Hurricanes are large, powerful storms that develop over oceans. Hurricanes gather heat and energy from warm ocean water. This heat increases the hurricane's power. A hurricane grows bigger and stronger the longer it remains over warm water. When a hurricane reaches land, heavy rain and strong winds damage buildings, cars, and trees. Flooding occurs when large waves called storm surges hit the beaches. Although hurricanes are dangerous, they weaken once they make landfall. Hurricanes are classified into five categories based on characteristics like wind speed and storm surge. This classification system is called the Safir-Simpson Hurricane Scale.

A tropical storm becomes a Category 1 hurricane when the winds reach 74 miles per hour. A Category 1 hurricane has wind that blows between 74 and 95 miles per hour. Its storm surge produces waves four to five feet above normal. Trees and shrubbery are usually the only things damaged during this type of storm. A Category 2 hurricane has wind speeds between 96 and 110 miles per hour. This type of storm damages shrubbery and trees. The roofs and windows of buildings can be slightly damaged. Its storm surge creates waves six to eight feet above normal. Some coastal areas may flood.



Category 3 storms have winds that blow between 111 and 130 miles per hour and a storm surge nine to 12 feet above normal. Large trees can be blown down and many buildings can be damaged. Mobile homes can be destroyed. Low-lying, coastal areas are in danger of flooding, and

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(Appendices continue)

people may be told to evacuate, or leave, those areas. Hurricane Katrina was a Category 3 storm when it hit southern Louisiana. Category 4 storms have wind speeds of 131 to 155 miles per hour. Their storm surge produces waves 13-18 feet above normal, and many areas are flooded. All shrubs, signs, and trees are blown down. Buildings suffer extensive damage, but mobile homes are usually completely destroyed.

Category 5 hurricanes are the most dangerous. They have wind speeds greater than 155 miles per hour. The storm surge creates waves greater than 18 feet above normal. Complete roof failure on buildings is often seen, and doors and windows are damaged. Mobile homes are usually destroyed. All shrubs, trees, and signs are blown down. Buildings within 500 yards, or five football fields, of the coastline are often flooded. People in coastal areas are evacuated and told to move to cities at least 20 miles away from the coast. Please circle the best answer

- 1. Which of the following hurricanes would be the strongest and most damaging?
 - a. A hurricane that took 1 day to reach land.
 - b. A hurricane that took 2 days to reach land.
 - c. A hurricane that developed over land.
 - d. A hurricane that took 1 week to reach land.
- 2. What is a storm surge?
 - a. The top speed of hurricane winds.

- b. Large waves caused by a hurricane.
- c. The center of a hurricane.
- d. The time it takes for a hurricane to make landfall.
- 3. Which of the following would make a good title for this reading passage?
 - a. The Eye of the Storm
 - b. The Safir-Simpson Hurricane Scale.
 - c. Hurricane Damage
 - d. Hurricane Katrina
- 4. Which of the following people would probably be told to leave the area first if a hurricane were about to hit?
 - a. A person living 10 miles from the beach in a house.
 - b. A person living one block from the beach in a house.
 - c. A person living 25 miles from the beach in a mobile home.
 - d. A person living five miles from the beach in an apartment complex.
- 5. What is the main idea of this passage?
 - a. Hurricanes are large, dangerous storms.
 - b. Hurricanes develop quickly over land.
 - c. Hurricanes gather energy when they are over warm water.
 - d. Hurricanes are classified by their wind speed and storm surge.

Appendix B

Equations for Hierarchical Linear Modeling

Model	Outcome			
Fully unconditional models two-level model	Level 1: Outcome _{ii} = $\beta_{0i} + \beta_{1i}$ [time] + r_i Level 2: $\beta_{0i} = \gamma_{00} + u_{0i}$ $\beta_{1i} = \gamma_{10} + u_{1i}$			
RQ1: Intervention effects on reading comprehension and reading motivation				
Intercepts and slopes as outcomes	Level 1: Outcomes _{it} = $\beta_{0i} + \beta_{1it}$ [time] + r_{it} Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}$ [cond] + u_{0i} $\beta_{1i} = \gamma_{10} + \gamma_{11}$ [cond] + u_{1i}			
RQ2: Prior comprehension moderating the relationship between treatment and reading motivation				
Moderator analysis	Level 1: RM Outcomes _{it} = $\beta_{0i} + \beta_{1i}$ [time] + r_i Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}$ [cond] + γ_{02} [Pre_GSRT] + γ_{03} [cond × PreGSRT] + u_{0i} $\beta_{1i} = \gamma_{10} + \gamma_{11}$ [cond] + γ_{12} [Pre_GSRT] + γ_{13} [cond × PreGSRT] + u_{1i}			

Note. Level 3 fully unconditional models did not reveal significant variability at Level 3; hence Level 2 models are used. RQ = research question; cond = condition; RM = reading motivation; GSRT = Gray Silent Reading Test.

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