

## ABSTRACT

SHORES, LUCY R. Situational Interest and Informational Text Comprehension: A Game-Based Learning Perspective. (Under the direction of John L. Nietfeld).

Motivated by disturbing national educational statistics, the newly adopted Common Core State Standards (Common Core State Standards, 2010) prioritizes reading instruction across the content areas significantly increasing students' exposure to informational texts—texts notorious for low comprehension rates and less than engaging content. Given the substantial literature supporting the positive relationship between situational interest and reading comprehension (Schraw, 1997), this study addressed whether game-based learning environments generate situational interest and, more importantly, whether the produced situational interest increases students' reading comprehension for informational texts within this context. Using an explanatory sequential mixed methods design eighth-grade students' situational interest and comprehension of texts embedded within a science game-based learning environment were compared to levels of situational interest and comprehension for students in a paper-pencil, classroom-based version of the gaming environment as well as to students learning from a PowerPoint. Findings from this study revealed the game-based learning environment, CRYSTAL ISLAND: LOST INVESTIGATION, to be significantly superior for triggering *and* sustaining levels of situational interest as compared to the other conditions. Furthermore, situational interest generated by the experimental manipulations was found to be a significant predictor of application-level reading comprehension above and beyond prior knowledge, reading ability, and personal interest, a finding consistent with previous research. Lastly, components of the learning environments identified by the student as a source of interest were found to be analogous with that of the situational interest literature. This finding indicates game-based learning environments to be a potential platform for additional

situational interest investigations. Implications for this research include the design of game-based learning environments, the significant overlap between game-based learning and situational interest research, and the utility of using situational interest as a metric for the evaluation for game-based learning environments.

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Situational Interest and Informational Text Comprehension:  
A Game-Based Learning Perspective

by  
Lucy Robertson Shores

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APPROVED BY:

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Dr. John Nietfeld  
Committee Chair

---

Dr. James Lester

---

Dr. Anne McLaughlin

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Dr. James Minogue

## BIOGRAPHY

Lucy Robertson Shores was born in Birmingham, Alabama in 1986. She attended Homewood High School and graduated in 2004. Lucy then received an interdisciplinary Bachelor of Arts degree in Psychology and Computer Science from Rhodes College in Memphis, Tennessee in 2008. In 2010, she received a Master of Science degree in Computer Science from North Carolina State University under the supervision of Dr. James Lester. Lucy's research interests include applications of artificial intelligence for K-12 educational purposes. Currently, Lucy works as a Curriculum Specialist and Research Scientist at SAS Institute, Inc. in Cary, North Carolina.

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## TABLE OF CONTENTS

LIST OF TABLES .....	vii
LIST OF FIGURES .....	viii
CHAPTER ONE. Introduction .....	1
Study Purpose .....	3
CHAPTER TWO. Background.....	5
Comprehension of Informational Texts .....	7
Construction-Integration Model.....	9
Interest and Reading Comprehension .....	11
Interest and Learning .....	12
The Manifestation of Interest.....	15
Generating Situational Interest for Expository Texts .....	21
Game-Based Learning .....	28
Situational Interest and Games .....	30
Games for Informational Text Comprehension .....	37
CHAPTER THREE. Current Investigation .....	43
Research Questions and Hypotheses .....	45
Method .....	48
Participants.....	48
Materials .....	49
Procedure .....	56
CHAPTER FOUR. Analysis.....	60
Do digital game-based learning environments trigger and sustain greater levels of situational interest than classroom-based learning conditions? .....	63
Does situational interest generated through digital game-based learning affect reading comprehension for texts embedded within the environment? Does situational interest predict reading comprehension above and beyond other variables?.....	72
What components of digital game-based learning environments lead to greater levels of situational interest? .....	78
CHAPTER FIVE. Discussion.....	86
Implications for Educators.....	89
Implications for Educational Game Designers .....	90
Notable Limitations .....	91
Future Work .....	94
REFERENCES .....	97
APPENDICES .....	113
Appendix A. Relevant Instruments.....	114
Appendix B. Study Method Diagram .....	124
Appendix C. Expository Texts.....	125
Appendix D. Interview Protocol .....	143

Appendix E. Description of Conditions.....	144
Appendix F. Additional Multilevel Modeling Analysis .....	153
Appendix G. Interview Coding Manual.....	159

## LIST OF TABLES

Table 2.1. Definitions of a Proficient Reader as defined by the National Assessment Educational Progress.....	6
Table 2.2. Relevant working definitions.....	19
Table 2.3. Notable parallels between situational interest and gaming literature .....	34
Table 3.1. Expository texts' Lexile measure .....	52
Table 3.2. Study Schedule .....	56
Table 4.1. Overall Descriptive Statistics of Key Study Variables by Condition .....	61
Table 4.2. Correlation Matrix of Key Study Variables.....	62
Table 4.3. Means and Variance in Levels of Situational Interest by Condition .....	64
Table 4.4. Unstandardized Coefficients (and Standard Errors) of a Multilevel Model of Situational Interest.....	67
Table 4.5. Unstandardized Coefficients (and Standard Errors) of Multilevel Models of Situational Interest .....	70
Table 4.6. Passage Comprehension Means and Standard Deviations by Passage (Lexile Level).....	72
Table 4.7. Means and Variance in Levels of Application-Level Comprehension by Condition.....	73
Table 4.8. Hierarchal Linear Regression Predicting Comprehension at the Level of the Situation Model for All Conditions .....	74
Table 4.9. Hierarchal Linear Regression Predicting Comprehension at the Level of the Situation Model for All Conditions .....	75
Table 4.10. Hierarchal Regression Predicting Comprehension at the Level of the Situation Model by Condition.....	77

## LIST OF FIGURES

Figure 2.1. Factors influencing the actualized state of interest at any given time.....	17
Figure 2.2. CRYSTAL ISLAND: LOST INVESTIGATION game world (left) and informational text (right).....	39
Figure 3.1. Example PowerPoint slide.....	59
Figure 4.1. Between- and within-student partition of the variance.....	66
Figure 4.2. Levels of overall activity interest over time by condition.....	69
Figure 4.3. Student ratings for sources of situational interest.....	79
Figure 4.4. Student suggestions to what would have made the experience better.....	81
Figure 4.5. Reported sources and potential sources of situational interest for students in the game-based learning condition .....	83
Figure 4.6. Reported sources and potential sources of situational interest for students in the classroom-based learning condition.....	84
Figure 4.7. Reported sources and potential sources of situational interest for students in the PowerPoint condition.....	84

## CHAPTER ONE

### Introduction

Digital game-based learning environments are rapidly populating research agendas due to hypotheses supporting them as an effective way to promote sustained engagement with educational content. Fueled by the popularity of games for entertainment among teens (Pew, 2012), game-based learning environments couch curriculum within experiences designed to utilize game features such as challenge, fantasy, and narrative to engage all students, even those academically unmotivated (Gee, 2007; Prensky, 2007). Such environments have been developed and proven effective for teaching negotiation skills (Kim et al., 2009), foreign languages (Johnson, 2007) and scientific inquiry (Rowe, Shores, Mott, & Lester, 2010; Ketelhut, 2007). However, little research has focused on how game-based learning environments impact reading comprehension for informational texts that are often associated with low levels of comprehension (Garner, 1992).

Specifically, a great potential of game-based learning for reading comprehension lies in the glaring overlap between games and *interest*. The existing body of research in reading comprehension provides a myriad of evidenced-based best practices, one of which is how comprehension and learning from text is affected by student motivation, and more specifically, student interest (van Dijk & Kintsch, 1983; Hidi & Baird, 1986; Hidi, 1990; Krapp, Hidi, & Renninger, 1992; Schraw, Bruning, & Svoboda, 1995; Schiefele, 1999; Schraw & Lehman, 2001). Generally, higher levels of interest in a text are associated with heightened affective and cognitive processing resulting in deeper levels of comprehension

(Renninger & Hidi, 2011; Schraw, 1997); however we cannot expect all students to be *personally* interested in all aspects of all subjects. In fact, students often report low levels of interest for the topics found in classroom expository texts (Garner, 1992).

Fortunately, *situational interest*, temporary interest elicited by an individual's interpretation of environmental factors, has also been shown to positively affect levels of comprehension (Hidi, 1990; Schraw, 1990; Schraw & Lehman, 2001). Similar to personal interest, Hidi & Renninger (2006) suggest that both text-based and environment-based factors such as novelty (Bergin, 1999), cohesion (Bergin, 1999; Schraw, 1995), surprise (Bergin, 1999), puzzles (Mitchell, 1993), and narrative (Bergin, 1999; Schraw, 1995) trigger states of heightened affective and cognitive processing independent of prior experiences or personal interest. Therefore, the malleability of situational interest makes this construct especially appealing for classroom instruction. However, regardless of students' topic interest, informational texts are often incongruent with sources of situational interest and are instead commonly littered with cohesion breaks, information incompleteness, and implicit information (Garner, 1992). For this reason, researchers have turned to environmental-based manipulations (e.g., task instructions/prompts, level of activity) designed to not only promote interest in the topic of text, but also sustain interest in order to compensate for structural deficiencies (Guthrie et al., 2006).

Research investigating environmental-based manipulations for promoting student interest suggest hands-on, inquiry experiences that contextualize informational texts serve to mitigate common preclusions to student interest by making texts more coherent, complete,

and meaningful (Garner, 1992; Guthrie et al., 2006). While the majority of these studies have been conducted within the confines of the classroom, features present in many digital game-based learning environments (e.g., narrative, social interaction, fantasy, challenge, autonomy) align well with these strategies for generating situational interest (Garner, 1992; Guthrie et al., 2006). Consequently, game-based learning environments create a unique opportunity to investigate how environment-based manipulations might facilitate interest for informational texts and thereby positively affect comprehension.

### **Study Purpose**

Although both game-based learning and informational text comprehension are active areas of research, investigations into the effect of environmental contexts (e.g., hands-on activities, games) known to promote situational interest on reading comprehension are more limited (Guthrie, et al., 2006). Therefore, the purpose of this study is to empirically examine the theoretical benefits of game-based learning for generating student situational interest and subsequently impacting comprehension for informational texts. More specifically, this study will address whether the science game-based learning environment, CRYSTAL ISLAND: LOST INVESTIGATION, generates situational interest and, more importantly, whether the produced situational interest increases students' reading comprehension for embedded informational texts above and beyond more traditional classroom instruction.

Using an explanatory sequential mixed methods design, eighth-grade students' situational interest and comprehension will be measured quantitatively during and after interactions with CRYSTAL ISLAND: LOST INVESTIGATION. Interactions with CRYSTAL

ISLAND: LOST INVESTIGATION will be compared to a classroom activity designed to replicate the game-based experience in order to parse out the added affordances of digital learning. Comparisons will also be made to students engaging in a more traditional, lecture-style instruction theoretically less likely to generate situational interest. This analysis serves to better understand the benefits of more active, contextualized activities for expository text comprehension. Implications of this interdisciplinary work serve to expand the situational interest literature as well as best practices for game-based learning design and evaluation. Consequently, a qualitative phase will be conducted as a follow-up to the quantitative results in order to triangulate and further explain the findings. In this explanatory follow-up, informal interviews with a subset of the participating students will be conducted to verify student interest levels and identify components of the environment that impacted students' interest.

## CHAPTER TWO

### Background

The Common Core Standards (2010), now widely adopted across the nation, identify a set of English Language Arts and Mathematics skills necessary for postsecondary and occupational success. Such skills are introduced as early as developmentally appropriate and follow a vertical progression throughout primary and secondary education. Instead of designating *what* is to be taught and *when*, the Common Core Standards delineate competency levels for certain skills that a student should be able to demonstrate at the end of the school year (Common Core State Standards, 2010).

One significant modification yielded by the new Common Core Standards is the emphasis on reading skills (Common Core State Standards, 2010)—a change motivated by frightening statistics. Csikszentmihalyi (1990) writes, “we have become used to the idea that every person on the planet ought to know how to read and write”, which by no means the case in the United States (p. 116). Currently, only 34% of fourth graders, 34% of eighth graders, and 23% of twelfth graders in the United States are considered proficient readers (National Center for Educational Statistics, 2007, 2011; Table 2.1). The magnitude of these statistics is realized by studies that suggest reading proficiency is obligatory for learning in all disciplines, and deficiencies commonly associated with domain-specific skills can often be traced back to reading proficiency (Alvermann, 2001). Therefore, the Common Core Standards prioritize reading instruction by setting expectations for reading achievement across the subject areas (Common Core State Standards, 2010).

Table 2.1

*Definitions of a Proficient Reader as defined by the National Assessment Educational Progress*

	Grade 4	Grade 8	Grade 12
Definition of a Proficient Reader*	“Fourth-grade students performing at the <i>Proficient</i> level should be able to integrate and interpret texts and apply their understanding of the text to draw conclusions and make evaluations.”	“Eighth-grade students performing at the <i>Proficient</i> level should be able to provide relevant information and summarize main ideas and themes. They should be able to make and support inferences about a text, connect parts of a text, and analyze text features. Students performing at this level should also be able to fully substantiate judgments about content and presentation of content.”	“Twelfth-grade students performing at the <i>Proficient</i> level should be able to locate and integrate information using sophisticated analyses of the meaning and form of the text. These students should be able to provide specific text support for inferences, interpretative statements, and comparisons within and across texts.”

\* National Center for Educational Statistics, 2011

As a result, third through fifth grade classrooms can expect reading instruction evenly split between literature and informational texts, whereas 75% of sixth through twelfth graders’ readings will be comprised of informational texts from all disciplines (Common Core State Standards: English Language Arts, 2010). For the purposes of this report, informational texts will be defined as they are in the Common Core State Standards (Table 2.2): “Literary nonfiction and historical, scientific, and technical texts, which includes the subgenres of exposition, argument, and functional text in the form of personal essays, speeches, opinion pieces, essays about art or literature, biographies, memoirs, journalism,

and historical, scientific, technical, or economic accounts (including digital sources) written for a broad audience” (Common Core State Standards, 2010).

Namely, students at all reading levels will be taught, and therefore expected, to *learn* from text by identifying main ideas, analyzing text structure, integrating prior knowledge, making inferences, and using texts to generate and justify hypotheses (Common Core State Standards: English Language Arts, 2010)—skills associated with heightened cognitive processing demands, effort, and motivation. However, achieving proficiency of these skills across the classroom is by no means simple. For example, the overall trend of students’ motivation to complete academic tasks that demand higher order thinking decreases with age (Hidi & Harackiewicz, 2000). Also, the proliferation of scientific informational texts adds further complication, as these have been identified as particularly difficult due to uninteresting topics, information incompleteness, uncommon syntax and language, and lack of cohesion (Chambliss, 2002; Sinatra & Broughton, 2011). Needless to say, practitioners and researchers alike are investigating the most effective approaches for redesigning lessons and educational resources for successfully integrating informational texts within instruction. Therefore, a necessary first step is to thoroughly understand the problem.

### **Comprehension of Informational Texts**

Once basic literacy skills are developed, reading essentially becomes an activity motivated by a goal, and while our goal occasionally manifests as entertainment, the Common Core State Standards argues reading to acquire information is often required within educational and occupational settings (Common Core State Standards, 2010). Therefore, by

the time a student reaches secondary education, classroom readings are most often considered a learning resource, and comprehension transitions from an isolated understanding of the text to the extent to which the reader *learns* the text (Common Core State Standards, 2010).

Learning, as defined through a social cognitive lens, is an active and ongoing process of thoughtful, internal perception and elaboration of experiences and incoming information from an environment with existing schemata, or prior knowledge (Schunk, 2001; Bandura, 1986; Piaget, 1983). First, new information presented in a given environment is selected and interpreted by the individual based on prior knowledge and previous experiences. New and/or incongruent information results in a state of cognitive disequilibrium in which the individual is charged with resolving the conflict between the presented information and existing knowledge (Piaget, 1983). The individual must further engage with the material by gathering supplemental information and/or activating, elaborating, and connecting existing knowledge structures. Factors within the environment (e.g., resources, social interactions) as well as personal attributes are thought to mediate the efficiency and successful achievement of this effortful process.

Learning from a text adds further dimension to this process. In fact, “it borders miraculous how many subtasks people perform, how many points they keep track of, and how many constraints they respect when comprehending discourse” (van Dijk & Kintsch, 1983, p. 333). Here, the reader alone is charged with identifying important information and consequently making sense of the material. Therefore, the interpretation of information

within the text and the degree to which it is integrated with prior knowledge all depend on several cognitive and metacognitive factors, which helps to explain observed differences in levels of knowledge acquisition from reading observed between individuals. To better understand such differences, we turn to models of reading comprehension.

### **Construction-Integration Model**

While several models of comprehension exist (van Dijk & Kintsch, 1983; Pearson, et al., 1984; Graesser, et al., 1994; McNamara & Magliano, 2009), Kintsch's (1988) Construction-Integration model not only delineates the process of developing a mental representation of text, but also defines how this process leads to different levels of comprehension. Because of this distinction, the Construction-Integration model will be used to define levels of comprehension for the purposes of this report. Specifically, the model discriminates between the processes involved in fact-level recall and learning will be used to define levels of comprehension for the purposes for this report. In this model, the author discriminates between fact-level recall and learning by classifying recall as the ability to reproduce details of the text and learning as the ability to “infer new facts from the information, use it in conjunction with previous knowledge to solve novel problems, and integrate it with what was already known” (Kintsch, 1994, p. 294). First, in order for learning to occur, one must first achieve an understanding for the text during what is termed the construction phase. That is, one must “combine knowledge of the language as well as knowledge about the world” and creates a representation of the text in the form of a propositional network (Kintsch, 1988). Therefore, the formation of the textbase is a text-

driven, bottom-up process by which the surface-level understanding for each word or phrase is considered and semantic relations are formed.

From the construction phase, the reader creates the *situation model*. As the reader constructs the textbase, the propositional network spreads activation and associated activations are placed in working memory. Consequently, great cognitive demand ensues as the reader reasons with information from the textbase by eliminating irrelevant activations, supplementing prior knowledge, and/or establishing or strengthening connections between existing schemata (Bruning, et al., 2004; Kintsch, 1988). Ultimately, the reader's situation model manifests as a personal representation of the text's meaning comprised of associations between activated knowledge and the text and truly embodies comprehension.

van Dijk and Kintsch (1983) distinguish between the development of the textbase and the situation model by arguing, "learning from text is not usually learning a text" (p. 342). In other words, recalling facts from a text reflects comprehension at the level of the textbase, whereas reasoning, analyzing, and applying information from the text in order to create meaning demonstrates high levels of comprehension and the formation of a complete situation model (Kintsch, 1988). Therefore, in light of the Construction-Integration Model and the newly mandated competencies outlined by the Common Core State Standards, *reading comprehension* for the purposes of this report will be defined as an interaction of low and high level cognitive processes through which the reader integrates an interpretation of the text with prior knowledge in order to extract *meaning*.

In sum, social cognitive perspectives of knowledge acquisition suggest reading to learn is a complex, integrated process involving both environmental and internal factors, which appear to mediate the extent to which readers can and/or choose to put forth the requisite effort and learning strategies for reading comprehension (Bruning, et al., 2004; Kintsch, 1988; Baker & Wigfield, 1999). Aside from cognitive constraints such as working memory capacity, prior knowledge, and familiarity with specific reading strategies, *motivated* readers have been shown to demonstrate deeper levels of comprehension than non-motivated readers (Baker & Wigfield, 1999; Schiefele, et al., 2012). While factors that contribute to a reader's motivation are abundant, *interest* in a text's topic has proven to be especially instrumental for reading comprehension (Schraw, 1997; Renninger & Hidi, 2011).

### **Interest and Reading Comprehension**

Due to the frequency of its use in everyday conversation, connotations associated with the term *interest* are vast. Nonetheless, interest is often associated with conditions—internal or external to the individual—that yield inclination for engaging in an activity. With respect to education, Dewey (1913) suggested the degree to which a student learns is dependent upon effort he puts forth, and effort is regulated by interest in the task. More recently, empirical investigations have extended Dewey's (1913) hypothesis and produced two significant implications relevant to this report: 1) interest manifests as heightened cognitive and affective processes and, consequently, influences what and to what extent students learn (Schraw & Lehman, 2001; Renninger & Hidi, 2011; Dewey, 1913), and 2) the instantiation of interest is highly dependent upon an interaction between person and context

(Hidi & Renninger, 2006; Hidi, et al., 2004). These implications are described further in the following sections.

### **Interest and Learning**

While references to the role of interest in learning dates back to Dewey's (1913) theoretical work, *Interest and Effort in Education*, it was not until the 70's that empirical interest research began to appear in the literature. As a result of this movement, a great deal of interest-related research focused on the role of interest for text comprehension. For example, within a larger text, segments rated as particularly interesting are recalled significantly better than those perceived as less interesting and even those rated as important (Schraw & Dennison, 1994). Also, Schiefele (1990) found students highly interested in the topic of an expository text performed better on questions requiring inferences, transfer, and synthesis than those reporting low levels of interest *independent of prior domain knowledge and cognitive ability*; however, no differences were found between the groups for simple fact-recall questions.

Interpretations of these findings imply that regardless of interest, students generate surface-level models of the text, but the additional effort required for developing sophisticated situation models appears to be mediated by interest (Schiefele, 1992). Similar studies expanding upon Schiefele's (1990; 1996) work support the findings (Schraw, 1997; Renninger, et al., 2002; Ryan, et al., 1990; Schaffner & Schiefele, 2007; Clinton & van den Broek, 2012) and add the effect of interest on deep levels of comprehension appears to independent of reading ability and interest for reading (Renninger, et al., 2002). Moreover, a

meta-analysis conducted by Pugh and Bergin (2006) found interest to be predictive of transfer.

Given these results, investigations into the nature of interest transpired and revealed interest to be a particularly unique motivational construct yielded through a bi-directional interaction of cognitive and affective processes. Working in tandem, the dual processes appear to optimize cognitive processing and facilitate motivation for prolonged engagement (Hidi, et al., 2004), as delineated in the following sections.

**Cognitive Processes.** As outlined previously, learning from text—or, the construction of a robust situational model—is generally dependent on the breadth and depth of cognitive processing in working memory, which is known to be limited by capacity constraints (Bruning, et al., 2004; Kintsch, 1988). However, Hidi and colleagues (2004, 2001) argue readers automatically allocate attention toward attributes perceived as interesting thereby admitting cognitive capacity for additional processing such as those facilitating deeper comprehension. For justification of this hypothesis, Hidi points to work lead by McDaniel (2000).

While reading a text, McDaniel and colleagues (2000) asked participants to respond to a secondary probe task that required participants to react to the sound of a tone by pressing a button. Participants rating texts as “interesting” demonstrated significantly faster response times, which the authors interpreted as more effective use of cognitive resources. In sum, the authors concluded low-interest stories require greater cognitive demand as more effort is

necessary to focus attention (McDaniel, 2000). In line with these findings, cognitive processes such as inference generation (Clinton & van den Broek, 2012) and elaboration of information with prior knowledge (Schiefele, 2004) have been identified as mediators between interest and learning.

**Affective, Conative, and Self-Regulatory Processes.** While cognitive activity elicited by interest is associated with deeper levels of comprehension, motivation to begin and persist during a reading task are hypothesized to be consequent of affective and conative processes. Work by Ainley and colleagues (2000; 2002) found affective responses to the presentation of a reading topic mediate the relationship between interest and learning from a text. Participants reporting positive emotional reactions to a given topic were more likely to persist throughout the reading and thus demonstrated greater comprehension than participants reporting negative or neutral emotional responses (Ainley, 2000). Extending these findings, Ainley (2005) found shifts from positive to negative or neutral emotions such as boredom to be predictive of when students would disengage during a reading activity. Similarly, Csikszentmihalyi's (1990) flow theory suggests topic interest is predictive of experiencing the state of flow during reading (Schiefele, 1992). Furthermore, segments of texts garnering an emotional response tend to be better remembered than non-emotional segments, even after a significant delay (Sadoski & Quast, 1990; Ryan, et al., 1990).

Longitudinally speaking, familiarity with interest-related tasks and positive emotions associated with previous accomplishments nurture the development of interest (Hidi & Renninger, 2006; Schiefele, et al., 1992); thus, in general, individuals are more motivated to

engage in activities that align with their existing interests (Denissen, Zarrett, & Eccles, 2007). This interest-based inclination has been shown to foster academic achievement (Schiefele, et al., 2004).

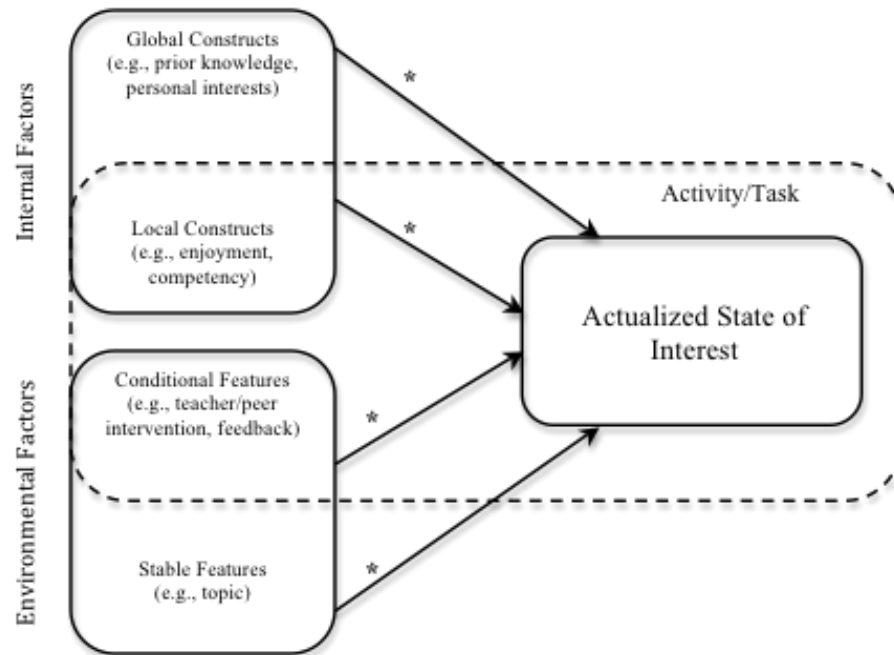
From a self-regulatory perspective, interest has been identified as a strategy for maintaining motivation to complete a task (Sansone, et al., 1992; Sansone & Thoman, 2005). Following perceptions of boredom, participants in a study by Sansone and colleagues (1992) employed strategies such as adding meaning or game-like attributes to facilitate a state of interest. As a whole, participants reported the use of interest as a self-regulatory mechanism for motivation more often than other strategies (Sansone, et al., 1992).

In sum, empirical evidence justifies the importance of interest for text comprehension. The state of interest engages productive cognitive and affective processes that facilitate deep levels of comprehension and, consequently, learning from a text. Moreover, the power of topic interest appears to influence above and beyond other factors known to increase comprehension such as prior knowledge, general intelligence, and working memory capacity.

### **The Manifestation of Interest**

Beyond the benefits for reading comprehension, the malleability of interest further justifies its importance. As opposed to other dimensions of motivation (Schiefele, et al., 2012), the motivational effects of interest are dependent upon an interaction between an individual and particular task conditions (Figure 2.1). In other words, only when individuals *perceive* information from a given environment (e.g., text structure, text content, activity features) as

interesting do consequent cognitive processing and affective response ensue (Renninger & Hidi, 2011). Therefore, internal cognitive and/or affective constructs such as prior knowledge and existing interests in conjunction with task conditions stimulate the manifestation of an actualized state of interest. From there, internal processes such as feelings of enjoyment and competency brought on by the task itself as well as real-time changes to the environment (e.g., teacher intervention) further influence intensity and duration. However, of great importance, the weight of influence afforded by each of these sources is highly dependent (Hidi & Renninger, 2006). Perceptions of interest transcend previous experiences and predispositions as evidenced by spontaneous instantiations of interest supported by certain environmental conditions that inherently generate cognitive and/or affective response regardless of prior experiences (Hidi & Renninger, 2006). Therefore, theoretical conceptualizations of interest—namely Hidi and Renninger’s (2006) Four-Phase Model of Interest Development—suggests interest is developed overtime making the construct instrumental for lifelong learning (Hidi & Renninger, 2006; Krapp, 2002).



\*Weight of influence is dependent upon the specific activity/task and individual differences

Figure 2.1. Factors influencing the actualized state of interest at any given time.

For this reason, the literature differentiates between *individual or personal interests* and *situational interests* (Renninger & Hidi, 2011; Schraw & Lehman, 2001; Krapp, 1989; Schiefele, 1991). Personal interests are thought to be “relatively stable and are usually associated with increased knowledge, positive emotions, and increased reference value” (Krapp, et al., 1992, p. 6; Table 2.2). Schiefele and colleagues (2012) distinguishes between personal interests and other reading motivations in that individuals with a well-developed personal interest habitually engage in topic-related tasks simply because of the content, not the context or other task features. Therefore, when tasks associated with personal interests

are presented, the topic alone motivates individuals put forth necessary cognitive effort because of an intrinsic motivation for and positive affect associated with knowledge building.

In contrast, situational interest arises irrespective of personal preference for a topic through external attributes that inherently yield changes in cognitive and affective processes (Hidi & Renninger, 2006; Krapp, et al., 1992; Schraw & Lehman, 2001). In other words, the actualization and intensity of situational interest are dependent upon the presence of aspects in the environment that, when interpreted by an individual, inherently produce a cognitive and affective response (Schmidt, et al., 2011; Renninger & Hidi, 2011; Krapp, 2002; Schraw, 1997; Bergin, 1999; Dewey, 1913). Hidi and Renninger (2006) argue the state of situational interest is almost exclusively supported by external influences. Once situational interest manifests, the extent to which the environment continues to scaffold and encourage the maintenance of cognitive and/or affective processes determines duration (Mitchell, 1993; Hidi & Renninger, 2006). Hidi and Renninger's (2006) model of interest development distinguishes between triggered and maintained situational interest and suggests contextual factors known to trigger situational interest do not necessarily sustain that state over time (Mitchell, 1993; Bergin, 1999; Palmer, 2009).

Aside from the academic benefits garnered by situational interest, situational interest in a topic or activity is also thought to be a necessary first step to the development of personal interest in that topic or activity (Hidi & Renninger, 2006). After a period of sustained situational interest (or a series of situationally interesting events), Hidi and Renninger (2006) suggest individuals begin to enter the "emerging personally interest"

phase, which ultimately leads to “well-developed personal interest” in a particular topic or activity. Once personal interest in the topic is attained, the state of interest is thought to be almost exclusively self-generated and, therefore, optimal for independent, life-long learning (Hidi & Renninger, 2006).

Table 2.2

*Relevant working definitions*

Construct	Definition
Reading Comprehension	An interaction of low and high level cognitive processes through which the reader integrates an interpretation of the text with prior knowledge in order to extract <i>meaning</i> (McNamara & Magliano, 2009; Kintsch, 1988).
Informational Text	“Literary nonfiction and historical, scientific, and technical texts, which includes the subgenres of exposition, argument, and functional text in the form of personal essays, speeches, opinion pieces, essays about art or literature, biographies, memoirs, journalism, and historical, scientific, technical, or economic accounts (including digital sources) written for a broad audience” (Common Core State Standards)
Personal Interest	A relatively stable intrinsic inclination to engage in cognitive and affective processing based on previous experience, knowledge, positive affect, and increased reference value (Krapp, et al., 1992; Hidi & Renninger, 2006).
Situational Interest	An actualized psychological state arising as the product of a conditional interaction between person and context (Renninger & Hidi, 2011; Schraw, 1997; Bergin, 1999; Dewey, 1913), developed through a progression of stages (Mitchell, 1993; Hidi & Renninger, 2006; Krapp, 2002), associated with effortless, heightened cognitive processing (Hidi, et al., 2004; McDaniel, et al., 2000), and instrumental in generating meaningful connections with prior knowledge (Dewey, 1913; Renninger & Hidi, 2011; Schraw, 1997).

Given its relative adolescence, abstractness, and complexity, an agreed-upon, concrete definition of situational interest does not exist in the literature. However, for the purposes of this report, situational interest will be defined as: an actualized psychological state of cognitive and affective engagement arising as the product of a conditional interaction between person and context (Renninger & Hidi, 2011; Schraw, 1997; Bergin, 1999; Dewey, 1913), developed through a progression of stages (Mitchell, 1993; Hidi & Renninger, 2006; Krapp, 2002), associated with the automatic allocation of attention (Hidi, et al., 2004; McDaniel, et al., 2000), and instrumental in facilitating deep levels of reading comprehension (Dewey, 1913; Renninger & Hidi, 2011; Schraw, 1997; Table 2).

The aforementioned distinction between situational and personal interest, entails learning contexts are sufficiently effective for promoting academic motivation. Thus, the true utility of situational interest lies in its manipulability due to the conditional constraints described previously. As evidenced by numerous findings in the literature (Bergin, 1999; Schraw, 1995; Palmer, 2009; Guthrie, et al., 2006), the state of situational interest is primarily governed by environmental factors (Hidi & Renninger, 2006), and therefore, “under the direct control of educators” (Rotgans & Schmidt, 2011, p. 37). For this reason, situational interest is often identified as the proverbial key for addressing the divergence between ideal and observed states of student motivation in academic settings (Hidi & Harackiewicz, 2000). The following section describes practical research related to the generation of situational interest for academic settings.

### **Generating Situational Interest for Expository Texts**

Theoretical discussions, empirical investigations, and anecdotal reports of situational interest all draw a common conclusion: situational interest is a powerful tool for enhancing comprehension and facilitating meaningful learning from text (Schiefele, 1999; Schraw, 1997; Zahorik, 1996). Despite existing levels of motivation or preference for a given topic, teachers can leverage sources of situational interest in order to temporarily manifest student interest and reap the affective and cognitive benefits (Krapp, 2002; Rotgans & Schmidt, 2012). The longer the environment sustains interest, the more the student is likely to persist and engage in meaningful cognitive processes of information (Ainley, et al., 2005; Hidi, et al., 2004). However, the effective utilization of situational interest in the classroom requires a careful understanding of its wide-range of sources.

**Sources of Situational Interest for Text.** By definition, the state of situational interest is brought about by spontaneous changes in affective and cognitive processes as consequence of environmental conditions (Krapp, 1992; Renninger & Hidi, 2011; Table 2.2). Therefore, sources of situational can be generally assigned to one of two categories: 1) factors that trigger and facilitate cognitive activity (e.g., cognitive dissonance, cohesion) or 2) attributes that generate an emotional response (e.g., seductive content, social interaction, illustrations) (Hidi & Renninger, 2006). Moreover, the duration of a state of interest is dependent upon how well the environment supports continued cognitive and affective activity, which is often supported through sources divergent to those responsible for triggering the state (Hidi & Renninger, 2006).

However, attempts at generating situational interest must be done with care, as hastily integrating identified sources of situational interest can undermine the benefits of this state and even lead to a negative effect on learning (Magner, et al., 2012; Harp & Mayer, 1997, Garner, 1992). For example, teachers report adding “bells and whistles,” or seductive content, to their lesson plans as a ploy for generating student interest (Zahorik, 1996); however, when the seductive material is integrated without consideration of the target content, the lesson is subject to the *seductive detail effect*—generating situational interest for the added details as opposed to the targeted material (Harp & Mayer, 1997; Garner, 1992). In terms of reading to learn, students activate schemata associated with the seductive content as opposed to the important details and attempt to develop their situation model for the text accordingly (Garner, 1992). Students also are inclined to generate interest for the added, irrelevant details as opposed to the targeted material eliminating the possibility of developing personal, long-term interest (Hidi & Renninger, 2006; Dewey, 1913; Garner, 1992). Furthermore, the addition of seductive details to instructional materials has been shown to negatively affect students’ ability to transfer (Abercrombie, 2013). Therefore, it is only when interestingness and importance overlap, that the beneficial effects of situational interest on reading to learn are realized (Wade, et al., 1999; Hidi & Baird, 1986).

As the target material in academic settings often involves the acquisition of knowledge, the interest literature commonly recommends integrating environmental conditions that generate situational interest through triggering and maintaining cognitive processes. For example, Palmer (2009) explains texts and environmental conditions can

generate interest by inducing cognitive dissonance, which automatically activates cognitive processes targeted at re-establishing cognitive equilibrium; thus, the consequential cognitive shift triggers situational interest. Research suggests situational interest is maintained when environments provide context and meaning that guide appropriate activation of prior knowledge (Mitchell, 1993). For example, students unable to make sense of the incoming information alone must rely on external scaffolds (e.g., teacher/peer, classroom discussion, or supplemental resources) in order to make connections with prior knowledge and generate understanding (Palmer, 2009). Furthermore, as opposed to seductive content, Mitchell (1993) argues environmental conditions can leverage appealing affective components such as social interaction, autonomy, and interactivity to not only enhance learning but further maintain situational interest (Mitchell, 1993; Bergin, 1999; Hidi & Renninger, 2006).

Empirical support for sources of situational interest can be found throughout the literature (Flowerday & Schraw, 2012; Rotgans & Schmidt, 2012; Bergin, 1999; Schraw, et al., 1995; Mitchell 1993; Hidi & Baird, 1998). With respect to texts, readers have been shown to rate segments of text that reflect novelty (Hidi, 1990), surprise (Anderson, et al., 1987), suspense (Jose & Brewer, 1984), fantasy (Malone & Lepper, 1990), seductive content (Bergin, 1999; Wade, et al., 1993), incongruence (Bergin, 1999), and thematic complexity (Schraw, 1997) as particularly interesting. Furthermore, text factors that facilitate sustained cognitive processing and affective response such as coherence (O'Brien & Myers, 1999), relevancy (Schraw, et al., 1995), vividness (Garner, 1992), narrative (Schraw, 1995), and information completeness (Schraw, 1997) are often considered particularly interesting. In

such cases, the more the text provides readers with sufficient information meaning, and support to engage in adequate cognitive processing the more robust the situation model, which yields deeper levels of comprehension (Schiefele, 1991, 1999).

However, the appeal of generating situational interest in the science classroom is often short-lived as informational texts in the classroom are notoriously rid of the aforementioned characteristics (Garner, 1992; Sinatra & Broughton, 2012). In fact, students rarely rate important segments of expository texts as interesting (Hidi, Baird, & Hildyard, 1982; Garner, et al., 1991), and often complain of lack of cohesion and incomprehensibility (Sinatra & Broughton, 2012). Not only do expository texts lack features that trigger situational interest, but also, students often have a difficult time activating appropriate knowledge structures and contextualizing the information, which impedes sustained situational interest (Garner, 1992). Moreover, past experiences with expository texts can conflict with perceptions of competency and appropriate challenge also leading to lack of interest (Shirey, 1992).

While some investigations into the manipulation of informational texts for increasing comprehension have proven effective (Beck, et al., 1991; Schraw, Flowerday, & Lehman, 2001), this method is often impractical for several reasons: a) systematic processes for revising texts are not well established (Beck, et al., 1991) b) compiling a collection of texts rich in the aforementioned characteristics across the curriculum is difficult (Garner, 1992); c) students will ultimately be expected to learn from expository texts as is (Common Core State Standards, 2010), and d) interesting, seductive details can interfere with comprehension and

recall of main ideas (Garner, 1992; Harp & Mayer, 1998). Fortunately, manipulations to the conditions surrounding a reading session have shown promise for facilitating situational interest for informational texts.

**Task-based manipulations.** Given the constraints of informational texts, activities that contextualize the reading task are often more conducive for both triggered and sustained situational interest (Guthrie, et al., 2006). While it is difficult to integrate elements of narrative, fantasy, meaningfulness, belongingness, or interactivity into an expository text, reading prompts or activities have the potential to embody such conditions and scaffold the amalgamation of importance and interestingness ratings within the reading task. In other words, pre- and/or post-reading activities can trigger situational interest and also compensate for lack of cohesion and information completeness (Schraw, et al., 2001). Consequently, students should experience a reduction of cognitive load allowing for more effective processing and the production of a robust situation model (Schraw, et al., 2001; Bruning, et al., 2004; Kintsch, 1988).

One method for generating situational interest for important aspects of a text is priming relevant schemata before or after reading (Schraw & Dennison, 1994; Hidi, 1990). For example, Schraw and Dennison (1994) found manipulating a reader's purpose affects ratings of interestingness and comprehension for the text. The authors argue by assigning a particular perspective to take while reading, certain schemata are activated, which influences readers' perceptions of importance and interestingness. Perspective-relevant portions of the text were rated as interesting and recalled better than non-relevant portions. Participants

asked to take a different perspective rated segments much differently with little overlap between conditions. Effects were found even when perspective instructions were administered after reading the text (Schraw & Dennison, 1994). Therefore, discussions or reading instructions that activate relevant knowledge and establish purpose for reading scaffold meaning making and thus generate situational interest for the targeted material.

Expanding upon this finding, integrating reading tasks within larger, inquiry-based learning experiences has recently surfaced in the situational interest literature (Palmer, 2009; Rotgans & Schmidt, 2011). Inquiry-based learning contexts promote active knowledge construction by providing settings in which the student must take control of his/her own learning, by setting their own goals, and working at an appropriate pace for his/her level of understanding (Palmer, 2009). Therefore, inquiry-based learning can trigger affective response through factors such as social interaction, interactivity, autonomy, and choice while also inducing cognitive dissonance by providing learning challenges or problem-solving scenarios. Consequently, task conditions then trigger and scaffold affective response and productive cognitive activity by facilitating active knowledge construction, understanding, and success thereby maintaining situational interest throughout the task (Palmer, 2009). Such conditions align well with the situational interest literature in that inquiry-based learning tasks involve interactivity and situate the activity within a meaningful structure (Mitchell, 1993).

Although inquiry-based learning theory is well documented, the intersection of this instructional method as a means for increasing situational interest and reading

comprehension is quite scant. Rotgans and Schmidt (2010, 2011) measured situational interest at five time points during an inquiry-based learning session and found inquiry-experiences to trigger situational interest, but also sustain situational interest especially when conditions appeal to cognitive engagement. Similarly, Palmer (2009) found students engaging in inquiry-based learning experienced significantly higher levels of sustained situational interest throughout the interaction than students in a traditional lecture setting. However, these studies did not integrate investigations of situational interest for informational texts and text comprehension.

With respect to informational text comprehension, Guthrie and colleagues (2006) found by incorporating informational texts with stimulating, hands-on interactions, comprehension increased. The study's results implied by completing the hands-on activities, students were able to contextualize the informational text reading. The activity compensated for the structural limitations of the informational text by scaffolding the activation of prior knowledge and identification of important information while reading; thus, students could more easily, efficiently, and thoroughly process information from the text in order to develop the situation model. While the investigation assessed motivation, situational interest was only hypothesized in the conclusion, not directly measured.

Surprisingly, game-based learning remains practically untapped in terms of research aimed at promoting situational interest and more specifically, promoting situational interest for enhanced comprehension. Although interest researchers and game-based learning researchers rarely overlap, their goals are the same: integrating elements known to generate

cognitive and affective engagement for educational content. Games for learning proponents (e.g., Prensky, 2007; Gee, 2013) as well as educational psychologists (e.g., Hidi & Harackiewicz, 2000) have argued that traditional instructional methods are becoming antiquated and no longer meet the motivational needs of the 21<sup>st</sup> century learner—a problem potentially mitigated by introducing games into the classroom (Prensky, 2007). Nonetheless, a review of the most recent interest literature conducted by Renninger and Hidi (2011) makes no mention of game-based learning as a method for manipulating the learning environment in order to promote situational interest. Moreover, a recent meta-analysis of game-based learning only reports studies concerned with motivation as a whole, not situational interest specifically (Connolly, et al., 2012). The following section expounds the rationale for game-based learning, the parallels with research on interest, the potential of games for literacy, limitations of past research, and considerations for future work.

### **Game-Based Learning**

For centuries games of all types have entertained populations around the world. Complex or simple, single-player or multiplayer, active or sedentary, games are entertaining, motivational, and seem to effortlessly command our attention. Not only do we become captivated during play, often games require learning various rules and constraints, problem solving, critical thinking, time management, and other educationally relevant skills (Gee, 2007; Prensky, 2007). Therefore, James Gee (2003) argues the application of such skills in a gaming setting provides justification for the conclusion that students do in fact possess these competencies, but are often not motivated by traditional classroom experiences to apply them

at school. The same students unwilling to put forth necessary effort in the classroom engage in cognitively demanding and exhausting games for hours outside of school (Gee, 2003; Prensky, 2007). Moreover, using a diverse population of middle school students ( $N = 786$ ), Marino (2012) found 90% of the sample expressed preference for gameplay compared to paper-and-pencil activities. For these reasons, researchers are aggressively investigating the potential for game-based learning as a means for enhancing 21<sup>st</sup> century education. Specifically, game-based learning environments integrate educational content and/or skills within a game framework in order to leverage the affective and cognitive states afforded by gameplay for pedagogical purposes.

The pervasive popularity of console, computer, and handheld games, has led to a recent surge of digital game-based learning environments. In fact, the 2012 K-12 edition of the Horizon Report expects widespread adoption of game-based learning technologies in the classroom within the next two to three years (Johnson, Adams, & Cummins, 2012). Moreover, several federal and private research funding agencies such as the National Science Foundation, the Bill and Melinda Gates Foundation, and the National Institute of Health, and the Department of Defense tout the potential of games and are substantially investing in their development.

While the game-based learning literature appears to be growing exponentially, two areas remain untapped relevant to this study. First, although the rationale motivating game-based learning is seemingly analogous with situational interest, explicit investigations into the correlation between the two are limited. Second, while games are hypothesized to ignite

student motivation regardless of previous experiences or feelings toward the content area, the motivational effects of game-based learning environments for reading comprehension are far less researched than other areas such as pre/post-reading activities and text-based features.

The following sections serve to further expound upon these two areas of need.

### **Situational Interest and Games**

Surprisingly, game-based learning and situational interest are rarely found jointly in the literature. In fact, recent meta-analyses from both research camps make no mention of the other (Renninger & Hidi, 2011; Connolly et al., 2012). Instead, gaming researchers and proponents often use terms such as *engagement* and *motivation*. On the other hand, interest researchers have yet to thoroughly explore the affordances of digital learning environments. However, after close analysis, it becomes clear that a primary goal of game-based learning is to simply harness elements of games to elicit situational interest for educational content (Table 2.2); therefore, the robust body of interest literature could serve as a theoretical framework for game design and evaluation.

**The Rationale for Game-Based Learning is Situational Interest.** The rationale supporting the game-based learning movement is grounded in the premise that games seem to elicit a level of motivation and effort often unparalleled and/or void in the classroom (Gee, 2003). Furthermore, it is not that games are simply a source of entertainment; Gee (2003) contends games incorporate 36 specific learning principles and success at any game requires a certain degree of *comprehension*. Players iteratively reason about game constraints, incoming information, and prior knowledge concerning general game tactics and previous

experiences and ultimately apply the resulting synthesis; therefore, if successful, players can generally speak to specific facts associated with the game, but more interestingly, provide an integrated report of how components of the game interact (Gee, 2003). In many games, players are in essence engaging in active, inquiry-based learning where the target content is often a domain outside those found in the classroom (Squire, 2005). However, educational games seek to combat motivational issues by embedding the same curricular topics that are perceived as boring the classroom within games in such a way to appeal to 21<sup>st</sup> century students' interests.

So, what is it about games? Why do players engage in higher-level cognitive processing during gameplay, but not in the classroom? In the well-cited book, *Digital Game-Based Learning*, Marc Prensky (2007) suggests games engage users because they are fun, novel, interactive, provide clear objectives, promote learning through feedback and outcomes, follow captivating narratives, and incorporate challenge, competition, and conflict. Moreover, games are thought to inherently trigger cognitive and affective activity by incorporating intrinsic motivators such as challenge, control, curiosity, and fantasy (Malone & Lepper, 1980). Players actively experience, rather than passively receive, information (Squire, 2005; Barab, et al., 2012). Therefore, when educational content is interwoven within games, learning is enhanced through meaningful experiences and interactivity, and the inherent learning principles of games (Prensky, 2007; Gee, 2007). Ultimately, game features hypothetically become a catalyst for persistence, motivation, focused attention, and positive affect (Prensky, 2007).

Evidence in favor of these theoretical stances has been cited for games ranging in both genre and domain (Connolley, et al., 2012). Actually, there is hardly debate surrounding the motivational power of games (Mayer, 2010). Most researchers, practitioners, and students alike agree if designed correctly, games have great educational potential (Prensky, 2001; Mayer, 2010). Moreover, evidence of significant learning gains during game-based learning has been reported (Barab, et al., 2012; Rowe, et al., 2010). Additional promise for the potential of games is supported by a compelling, recent study conducted by Marino and colleagues (2012). Middle school science teachers ( $N = 34$ ) representing 14 different states had their students ( $N = 876$ ) interact with two different game-based learning environments each designed to increase science content knowledge and encourage engagement. Based on classroom observations, the teachers found video games as an effective instructional tool due to their ability to captivate the attention of low-achieving, less engaged students (Marino, et al., 2012). Teachers reflected on observations of low-achieving students taking on leadership roles by showing other students how to navigate the game, and one teacher commented, “They were into the game so much that they didn’t really pay attention to the fact that they were learning something...and when we were studying, they’d go ‘remember in the game when that happened?’ ...They really did enjoy it” (Marino, et al., 2012, p. 9). However, while particular game features (e.g., narrative, novelty, gameplay, challenge, interactivity, and fantasy) and student behaviors (e.g., sustained attention, perceptions of meaningfulness and competency, and transfer of information) suggest the students experienced triggered and maintain situational interest, the study did *not* measure the construct specifically.

**Making Situational Interest a Priority for Game Design.** Despite the empirical optimism for the potential of game-based learning, opponents have claimed that games for learning do not adequately prioritize learning (Mayer, 2010; Sweller, 1999). The few positive reports supporting the efficacy of game-based learning are grossly outnumbered by studies producing less than impressive and even negative learning gains (Mayer, 2009; Mayer, 2010), and the less than optimal learning outcomes are often attributed to an inappropriate balance of entertainment and learning (Mayer 2010; Mayer, 2009; Rittenfeld & Weber, 2006). Similar to the seductive detail effect described previously with respect to considerations for promoting situational interest, students often become captivated by the “bells and whistles” as opposed to the targeted curriculum, which consequently impedes learning (Sweller, 1999). Proponents and opponents alike argue the optimal balance of features for engagement and features for learning has not been established (Prensky, 2001; Rittenfeld & Weber, 2006; Mayer, 2010).

Table 2.3

*Notable parallels between situational interest and gaming literature*

Sources of Situational Interest		References in Gaming Literature
Category	E.g.,	
Trigger	Cognitive Dissonance (Mitchell, 1992; Palmer, 2009; Bergin, 1999; Garner, 1992)	<ul style="list-style-type: none"> <li>• Novelty (Prensky, 2007; Marino, et al., 2012)</li> <li>• Conflict (Prensky, 2007)</li> <li>• Challenge (Prensky, 2007; Malone &amp; Lepper, 1980; Marino, et al., 2012)</li> <li>• Fantasy (Prensky, 2007; Malone &amp; Lepper, 1980)</li> <li>• Curiosity (Prensky, 2007; Malone &amp; Lepper, 1980)</li> </ul>
Maintain	Meaningfulness (Mitchell, 1992; Bergin, 1999)	<ul style="list-style-type: none"> <li>• Coherence</li> <li>• Relevancy</li> <li>• Vividness</li> <li>• Narrative</li> <li>• Information Completeness</li> <li>• Competency</li> </ul>
	Interactivity (Mitchell, 1992; Palmer, 2009; Flowerday & Schraw, 2012)	<ul style="list-style-type: none"> <li>• Social Interaction (Prensky, 2007; Marino, et al., 2012; Barab, et al., 2012; Squire, 2005)</li> <li>• Personalized Feedback (Prensky, 2007; Mayer, 2010)</li> <li>• Adaptation (Prensky, 2007; Barab, et al., 2012)</li> <li>• Play (Prensky, 2007)</li> <li>• Manipulables (Prensky, 2007)</li> <li>• Student as Protagonist (Barab, et al., 2012)</li> <li>• Active Learning (Squire, 2005; Barab, et al., 2012)</li> </ul>

However, when games are designed and evaluated with an interest lens, the nature of entertainment can be reconsidered. Situational interest theory suggests, like their classroom-based counterparts, game-based learning environments that incorporate inquiry experiences

generate interest, and therefore, motivation and effort, through attributes that stimulate cognitive *and* affective processing (Renninger & Hidi, 2011). Moreover, interest can theoretically be sustained if the environment incorporates elements that facilitate the production of meaningful connections with prior knowledge (Mitchell, 1993; Renninger & Hidi, 2011; Hidi & Renninger, 2006; Hidi & Harackiewicz, 2000). Within this framework, games should instead focus on scaffolding productive cognitive processing and affectively appealing factors should serve to *enhance* the activity such as social interaction and autonomy (Palmer, 2009). Superfluous elements that elicit affective response should be eliminated as their utility has been discounted in the literature (Garner, 1992).

Although games are rarely evaluated in terms of situational interest, games designed analogously with interest theory have proven to be more effective at attaining learning gains (Mayer, 2010; Rowe, et al., 2010; Shores, et al., 2012). Design considerations explicitly concerned with fostering effective cognitive processing have shown to positively impact products of learning within games (Mayer, 2010). For example, Mayer (2010) found activities geared at cognitive activity such as self-explanation to be an effective game feature for learning. Also, Quest Atlantis, intentionally couches gameplay within an over-arching authentic narrative in which students experience interactive learning situated within meaningful contexts (Barab, et al., 2012)—two identified sources of sustained situational interest (Mitchell, 1993). Consequently, students interacting with the game demonstrate greater learning gains than students in a traditional lecture (Barab, et al., 2012).

Recently, investigations with a similar narrative-based game for learning, Crystal Island, found students who effectively utilized a tool for scaffolding cognitive processing within the game not only produced greater learning gains, but also reported significantly higher levels of perceived situational interest (Shores, et al., 2012). Similar to Schiefele's (1991) studies with interest and reading comprehension, students reporting greater levels of situational interest only performed significantly better on application-level, not fact-level, content questions following the interaction. Given the apparent importance of interest on learning in this environment, necessary future work involves understanding the specific sources of situational interest within the game in order to avoid individual differences.

In sum, analyses of the game-based learning and situational interest literature point to a theoretically valid assumption that game-based learning environments are effective platforms for triggering and sustaining situational interest. Despite the scarcity of compelling support for games as an instructional method, recent progress in the field's understanding of effective design principles and advancements in technology suggest games for learning research should not be abandoned. In fact, Mayer (2010) reports, "the consensus is that there is a need for rigorous scientific research on what works with game design" (p. 245). Given the numerous parallels with interest, studies similar to those conducted in classroom-based scenarios that decompose a learning experience in terms of what activities/aspects serve to trigger and maintain situational interest should be replicated for game-based learning environments (Guthrie, et al., 2006; Rotgans & Schmidt, 2011; Palmer, 2009). Moreover, while preliminary reports of positive associations between learning in game-based

environments and perceived situational interest have been published (Rowe, et al., 2010), further investigations into the development and fluctuation of situational interest in games is needed.

### **Games for Informational Text Comprehension**

Grounded in implications from previous classroom-based work, game-based learning environments provide a unique platform for generating situational interest for informational texts embedded within the experience. As the proliferation of games for learning continues and the Common Core State Standards come into practice, investigations into the potential of game-based learning for literacy are particularly relevant. Specifically, capitalizing on game-based learning for the instruction of *scientific* literacy skills might serve particularly useful; since, in recent years, informational texts have garnered minimal attention in the science classroom often replaced by the theoretically more engaging interactive inquiry experiences (Sinatra & Broughton, 2011; Yore, et al., 2003). However, inquiry experiences and instruction involving informational texts do not necessarily require mutual exclusivity (Sinatra & Broughton, 2011).

Informational texts integrated within game-based learning can take on many forms depending on the context of the environment, which ultimately guides the formation of a robust and justified hypothesis for this framework for literacy instruction. Therefore, for the purposes of this report, consider the science game-based learning environment CRYSTAL ISLAND: LOST INVESTIGATION.

**CRYSTAL ISLAND: LOST INVESTIGATION.** The digital game-based learning environment provided by CRYSTAL ISLAND: LOST INVESTIGATION couches scientific reasoning, content knowledge, and competencies related to the comprehension and application of informational texts within an interactive, engaging 3D immersive world. CRYSTAL ISLAND: LOST INVESTIGATION revolves around a central problem-solving scenario that casts the student as the protagonist in a narrative-based plot to diagnosis a mystery illness plaguing other non-player characters within the game. Actions and behaviors required for success on the part of the player purposively goes beyond simple recall of content-specific knowledge and mandates the *application* of content, critical reasoning, justified hypothesis generation, scientific text comprehension, problem solving, and other skills utilized in both occupational and higher education settings.

Prior to playing CRYSTAL ISLAND: LOST INVESTIGATION students view a two-minute introductory video, which sets the stage of the central narrative. During the video, the student is cast as an investigator sent to the fictional Crystal Island (Figure 2) to diagnose a mysterious illness plaguing researchers who were stationed there to study the indigenous flora and fauna.

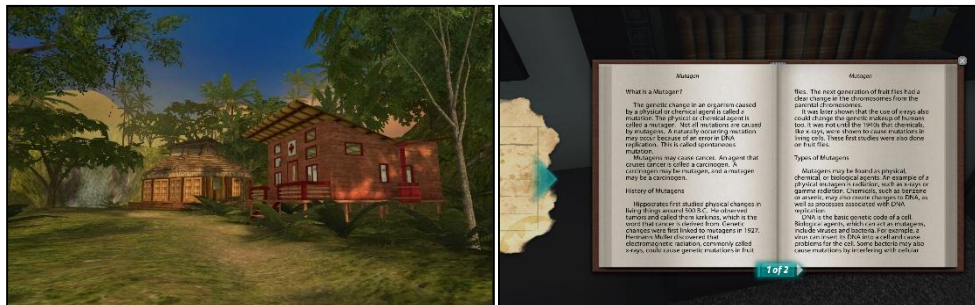


Figure 2.2. CRYSTAL ISLAND: LOST INVESTIGATION game world (left) and informational text (right).

Once game interaction begins, the student is introduced to several non-player characters including the camp nurse, Kim, who further explains the details of the illness and introduces resources on the island. In order to properly diagnosis the illness, the student is prompted to follow the steps of the scientific method and, thus, first collects relevant information. To do so, the student is free to interview sick team members, read relevant informational texts, speak with microbiology experts, and read posters displayed around the island. From here, the player can identify and test possibly contaminated objects, but must do so systematically as the testing facility has a limited power supply. At anytime during the interaction, students can view their *diagnosis worksheet* (Figure 3), a structured note-taking space designed to help students organize and reason with the gathered information. Once the host of the illness is identified, the player must synthesize the collected data, diagnosis the mystery illness, and present the findings to the camp nurse via the diagnosis worksheet before it is too late.

**1 Patient's Symptoms**

Symptom A	Symptom B
No entry	No entry
Symptom C	Symptom D
No entry	No entry

**2 Test Results**

I have tested:	The results showed:
Object A	No entry
Object B	No entry
Object C	No entry
Object D	No entry
Object E	No entry
Object F	No entry

**3 Possible Explanations**

	Likelihood:	Recourse:
Anthrax	No entry	No entry
Botulism	No entry	No entry
Ebola	No entry	No entry
Influenza	No entry	No entry
Salmonellosis	No entry	No entry
Smallpox	No entry	No entry

**4 Final Diagnosis**

Disease	No entry
Source	No entry
Treatment	No entry

Figure 2.3. The diagnosis worksheet, a structured note-taking space.

Using CRYSTAL ISLAND: LOST INVESTIGATION as a framework, opportunities for generating situational interest during the game, and more specifically, for the embedded informational text become more evident. With respect to the former, the environment integrates known sources of situational interest including narrative, social interaction, fantasy, and thematic complexity (Schraw, et al., 2001; Bergin, 1999; Mitchell, 1993). Furthermore, cognitive dissonance, a well-established source of situational interest (Mitchell, 1993; Schraw, 1995; Bergin, 1999), rendered by presenting challenge or puzzles manifests within Crystal Island through the introduction video, which explicitly defines the problem state. Attributes present throughout the game such as interactivity and affective and cognitive scaffolds (e.g., cognitive offloading tools, strategic hints, progress indicators, immediate feedback) have theoretically justified potential to maintain situational interest through

encouraging prolonged affective and cognitive processing (Mitchell, 1993; Bergin, 1999; Hidi & Renninger, 2006; Palmer, 2009).

Concerning the informational texts, aspects of the CRYSTAL ISLAND: LOST INVESTIGATION experience serve to compensate for interest-related shortcomings of structure and topic (e.g., information completeness, cohesion, relevancy), a common feature among scientific texts used in the classroom (Garner, 1992; Sinatra & Broughton, 2012). By contextualizing the texts within a highly-relevant problem-solving scenario, game experiences leading up to and following the reading task have the potential to foster the activation of prior knowledge, aid perceptions of relevancy, and scaffold the generation of inferences—all of which have been identified as methods for increasing situational interest for texts (Schraw & Dennison, 1994; Schraw, et al., 1997; Schraw & Lehman, 2001). For example, similar to the findings of Schraw and Dennison's (1994), prescribing a clear objective should lead players to perceive text-based information relevant to the goal as interesting and, in turn, comprehend this information more thoroughly.

Mentioned previously, classroom-based studies have demonstrated the efficacy of interactive, inquiry experiences for producing situational interest (Rotgans & Schmidt, 2011; Palmer, 2009) and the motivational impact these experiences have on reading comprehension (Guthrie, et al., 2006). Through careful examination of the similarities between situational interest and game-based learning literature, it becomes evident game-based learning environments potentially afford several opportunities for optimizing student academic effort and positively influencing levels of expository text comprehension. However, to date, such

hypotheses are purely speculative, as supporting empirical investigations have not yet been conducted.

## CHAPTER THREE

### Current Investigation

As classrooms begin to integrate the Common Core State Standards, pedagogical best practices and instructional methods for informational text instruction becomes a highly relevant research agenda (Common Core State Standards, 2010). Among the research-based factors shown to influence comprehension for informational texts, student interest has proven to be especially influential. Interest shown to predict levels of comprehension above and beyond variables such as prior knowledge, motivation for reading, and cognitive abilities (Schiefele, 1991; Schraw, 1997; Renninger, et al., 2002; Ryan, et al., 1990; Schaffner & Schiefele, 2007; Clinton & van den Broek, 2012). Moreover, because of its malleability, situational interest is largely “under the direct control of educators” (Rotgans & Schmidt, 2011, p. 37). For this reason, text-based, task-based, and student-based techniques for increasing student interest for comprehension have been reported (Schraw, 1997; Schraw, Flowerday & Lehman, 2001; Guthrie et al., 2006; Rotgans & Schmidt, 2011; Schraw & Dennison, 1994; Renninger et al., 2002; Schiefele, 1991).

Task-based manipulations, such as contextualizing texts within classroom-based inquiry experiences, has been shown to positively affect levels situational interest and, in turn, comprehension in traditional classroom settings (Guthrie et al., 2006; Rotgans & Schmidt, 2011; Schraw & Dennison, 1994), however little attention has been paid to leveraging digital game-based learning environments for this purpose. Like classroom-based inquiry experiences, digital game-based learning environments present students with

educational content through experiences rich in interest-generating features such as novelty, social interaction, interactivity, contextualization, and challenge. However, the effect of digital game-based learning experiences on student situational interest and reading comprehension has yet to be adequately explored. This study will examine the impact of the science digital game-based learning environment, CRYSTAL ISLAND-LOST INVESTIGATION, on situational interest and expository text comprehension for eighth-grade students.

The goal of this study is to expand upon classroom-based investigations aimed at utilizing inquiry experiences for informational text comprehension (e.g., Rotgans & Schmidt, 2011; Guthrie et al., 2006). Specifically, this work seeks to examine how interacting with CRYSTAL ISLAND-LOST INVESTIGATION impacts situational interest and, more importantly, whether the produced situational interest increases students' reading comprehension for informational texts above and beyond similar classroom-based activities. In order to parse out the added effects of digital game-based learning, eighth-grade students will be assigned to one of three conditions: digital game-based learning, classroom game-based learning, and PowerPoint learning. The classroom game-based condition will serve to replicate the digital game-based learning condition within the confines of the classroom. Thus, aspects such as the fantastical setting, character interactions, real-world simulations of working with laboratory equipment, and personalized feedback will be absent in the classroom game-based learning condition. The PowerPoint condition will simulate a traditional, lecture-style classroom instruction delivered on computer by presenting students with the same curricular content found in the other two conditions. Students in all conditions will be exposed to the

same seven expository texts, which will be embedded within the lesson. Levels of comprehension for the expository texts and situational interest will be compared across conditions. To examine the predictive power of situational interest, analyses will control for factors known to influence levels of comprehension including prior knowledge, reading ability, and prior interest. This work seeks to yield relevant implications for informational text instructional methods and best practices for educational game design.

### **Research Questions and Hypotheses**

In this study, the following research questions will be addressed:

- 1. Do digital game-based learning environments trigger and sustain greater levels of situational interest than classroom-based learning conditions?*

Considering the literature related to the sources of situational interest and the features of games theorized to foster educational effectiveness, it is hypothesized that students in the digital game-based learning condition will experience greater levels of situational interest than those in the classroom game-based and PowerPoint learning conditions. Moreover, it is expected students in the digital game-based learning and classroom game-based learning conditions will report higher levels of situational interest than those students in the PowerPoint learning condition.

Work conducted by Rotgans and Schmidt (2011) found classroom-based inquiry experiences to be effective for both triggering and maintaining levels of student situational interest over the course of the lesson. The authors explain their findings by pointing to known sources of situational interest (e.g., puzzles, hands-on activities, social interaction, and

challenge) embedded within the experience. However, the authors did not include other sources of interest such as technology (Mitchell, 1993), fantasy (Bergin, 1999), narrative (Bergin, 1999; Mitchell, 1993; Schraw, 1995), personalization (Mitchell, 1993), and choice (Bergin, 1999; Schraw, 1995; Schraw & Flowerday, 2012) all of which could be added through features of digital game-based learning.

In the current investigation, the digital game-based learning condition incorporates several sources of situational interest as described previously. While the classroom game-based learning condition serves to replicate this experience in the classroom as closely as possible, features such as technology and choice/autonomy are eliminated. Moreover, while elements such as fantasy, social interaction, personalization, and interactivity are present in the classroom game-based condition, these features are less realized than in the game-based experience. Given the presence of additional and more pervasive sources of situational interest in the digital game-based learning condition, it is hypothesized these students will report greater levels of situational interest throughout the course of the interaction.

2. *Does situational interest generated through digital game-based learning affect reading comprehension for texts embedded within the environment? Does situational interest predict reading comprehension above and beyond other variables?*

The Construction-Integration model of comprehension suggests learning from a text occurs by elaborating upon and actively integrating components of the text with prior knowledge in order to form a mental representation of the text known as the situation model (Kintsch, 1983). While prior knowledge and reading ability influence this process, the

situation model is also dependent upon the degree to which the student *can* and *will* engage with the text at this deeper level (Kintsch, 1983)—constraints affected by an actualized state of interest (McDaniel et al., 2000; Hidi et al., 2004). In support of this statement, previous investigations imply, when interested, readers tend to engage in the higher-order thinking necessary for comprehension independent of prior knowledge and cognitive ability (Schiefele, 1991; Schraw, 1997; Renninger, et al., 2002; Ryan, et al., 1990; Schaffner & Schiefele, 2007; Clinton & van den Broek, 2012). However, similar differences are typically not replicated for comprehension at the level of the textbase.

Given the presence of additional and more pervasive sources of situational interest in *CRYSTAL ISLAND: LOST INVESTIGATION*, it is hypothesized students in the digital game-based learning condition will demonstrate greater comprehension at the level of the situation model for the seven expository texts than students in the classroom game-based and PowerPoint condition. Moreover, as the PowerPoint condition integrates far fewer sources of situational interest, students in the game-based and classroom game-based conditions are expected to demonstrate greater comprehension at the level of the situation model than students in the PowerPoint condition. However, in line with previous findings (Schiefele, 1991; Clinton & van den Broek, 2012), differences between conditions for comprehension questions designed to measure students' representation of the textbase are not expected. Furthermore, it is hypothesized that students' reports of situational interest will predict levels of comprehension above and beyond prior knowledge, reading ability, and interest for reading in all conditions.

3. *What components of digital game-based learning environments lead to greater levels of situational interest?*

As presented in Table 2.3, several aspects of digital game-based learning have been identified as instrumental in adding to the effectiveness of this instructional method. However, Mayer and Johnson (2010) argue, to date, the benefits of games are greatly speculative, and, “there is a need for rigorous scientific research on what works with game design.” (p. 245). Given the overlap between “what works with” classroom-based manipulations for promoting situational interest and features of digital game-based learning, situational interest provides a logical and useful framework for the design and evaluation of educational games. Therefore, it is hypothesized students interacting with CRYSTAL ISLAND: LOST INVESTIGATION environment will point to the sources of situational interest described in the literature as “interesting” aspects of the experience.

## **Method**

### **Participants**

All eighth-grade students ( $N = 305$ ) from a large, socioeconomically diverse middle school (54% African American, 24% Hispanic, 18% White, 5% Asian/Pacific Islander; 47% reduced-price lunch eligible) were invited to participate in the study during their regular science class. Students were recruited from three classrooms all of which were in their 5<sup>th</sup> week of the microbiology unit; therefore, the study took place as part of their regular instruction. Results from the 2011-2012 school year end-of-grade tests indicate 46.4% of the

school's seventh-grade (now eighth-grade) students scored at or above grade level for reading (Department of Public Instruction, 2012).

Only students with signed parental consent forms and complete data were used for analysis leaving 154 students (81 female, 73 male). Of the remaining participants, 38% identified themselves as African-American, 40% White, 36% Hispanic/Latino, 10% Asian, 9% other. Ages ranged from 13-15 years old.

## **Materials**

Prior to experimental conditions, students completed the pre-test packet online (Appendix A). Specifically, the packet contained the following measures:

**Gaming Experience.** Gaming experience was assessed via questions for gaming preference and frequency. Specifically, using a 4-point Likert scale, students were asked to rank the degree to which they agree with statements such as, "I enjoy playing all types of videogames" and "I enjoy playing videogames more than other activities." Also, students were asked to estimate the number of hours per week they spend playing video games.

**Science and Reading Interest.** Measures of self-efficacy, task-value, task frequency, and general interest for science and reading were used to assess students' prior interest in the two relevant domains. The self-efficacy scale consists of twelve items answered on a 5-point Likert scale and was adapted from an inventory shown to be internally reliable (Nietfeld, Cao, & Osborne, 2006). The task-value scale consists of six, researcher-constructed items answered on a 5-point Likert scale intended to measure the extent to which the student feels learning science and reading is important or valuable. As seen in previous studies (Renninger

et al., 2002; Clinton & van den Broek, 2012), the interest survey consists of six, researcher-constructed items answered on a 5-point Likert scale in order to measure students' personal interest in science, microbiology, and reading. Also, students will be asked to rate their perceived science and reading skills on a 5-point Likert scale through a three-question, researcher-developed survey. Overall, the scale was found to be adequately reliable for this sample ( $\alpha = .80$ ).

Furthermore, students were asked to complete an abridged version of the Motivation for Reading Questionnaire (Wigfield & Guthrie, 1997) to assess intrinsic motivation for reading. The extended inventory consists of 54 items and is answered on a 5-point Likert scale; however, the inventory was shortened to 15 items to accommodate time restrictions. As personal interest has been equated to intrinsic motivation (Schiefele, 1999), results from the Motivation for Reading Questionnaire was also used as a baseline measure of reading interest. The modified scale was found to be sufficiently reliable for the sample used in this investigation ( $\alpha = .94$ ).

**Reading Achievement.** Selected tests from the Test of Reading Comprehension – 4<sup>th</sup> edition (TORC-4), a standardized test of silent reading comprehension, were used as a baseline measure of reading achievement. The TORC-4 was constructed for all students, but has also been previously used for measuring reading ability for both minority, struggling readers (Coarusso, Keel, & Dangel, 2001) and students who vary widely in their English proficiency (Mancilla-Martinez & Lesaux, 2010; Brown, Hammill, & Lee, 2011). Specifically, the test of relational vocabulary ( $\alpha = 0.92$ ) and text comprehension ( $\alpha = 0.95$ )

were used (Brown, Hammill, & Lee, 2011). The relational vocabulary requires the student to distinguish synonyms and antonyms. Students are asked to read a set of three words and identify the two words (of four) that are associated with the original set. For example, students will be given the words: eye, nose, arm, and asked to choose the 2 appropriate synonyms from the list: hair, air, legs, too. For the participants used in this study, the scale was found to be a reliable measure of relational vocabulary skills ( $\alpha = .86$ ). The text comprehension subtest is comprised of 12 short reading passages each with five corresponding comprehension questions: 1 question having students choose an appropriate title for the story, 2 questions intended to measure fact-level information, and 2 questions requiring students to make inferences. Again, this subtest was found to be a reliable measure of text comprehension for the study's sample ( $\alpha = .81$ ). Furthermore, in 2011 the TORC-4 was updated utilizing a norming sample of 1,942 students from 14 states. Furthermore, the TORC-4 has shown to be highly correlated with other tests of reading achievement (Brown, Hammill, & Lee, 2011).

**Microbiology Content Knowledge.** A researcher-constructed, 13-item microbiology multiple-choice content test was administered to establish a measure of relevant prior knowledge. By deconstructing the curriculum and the expository texts found within the CRYSTAL ISLAND: LOST INVESTIGATION environment, the test was deliberately developed to align with the embedded content. Moreover, test items were written to test both fact-level and application-level knowledge. Finally, content experts reviewed the items to ensure their validity, and the inventory was found to be adequately reliable for this sample ( $\alpha = .62$ ).

Table 3.1

*Expository Texts' Lexile Measure*

Title	Lexile Score	Word Count	Mean Sentence Length
Scientific Method	870L	132	12.00
How Do Diseases Spread?	980L	205	12.81
Immunization	1090L	278	15.83
Bacteria	830L	166	10.64
Viruses	910L	314	12.08
Salmonellosis	1000L	266	13.30
Influenza	1100L	406	15.04

**Expository Texts.** During the experimental conditions, students were exposed to seven expository text passages (Appendix C). The passage content is based on applicable microbiology concepts and written to be equitable in terms of reading level and length. To validate reading level, passages have been analyzed using the Lexile Framework (Table 3.1), which finds texts ranging between 805L – 1100L to be appropriate for readers in the eighth grade (MetaMetrics, 2012). Using a modified version of Rotgan and Schmidt's (2011) situational interest measure, students were asked to rank their current level of focused attention and affect using a 5-item, 5-point Likert scale questionnaire immediately after each passage (see Appendix A). Students in all conditions completed the situational interest measure using paper and pencil.

After students completed their respective activities in each condition they completed a post-test packet online (Appendix A). Items in the packet measured:

**Reading Comprehension.** For each of the seven expository texts, students were asked to answer four multiple-choice comprehension questions based on van Dijk and Kintsch's (1983) levels of comprehension. Among the several methods for measuring the textbase and situation model, multiple-choice fact and inference questions have often been utilized (e.g., Salmeron, Canas, Kintsch, & Farjado, 2005; McNamara, Kintsch, Songer, & Kintsch, 1996). Therefore, two questions were fact-level questions intended to access students' textbase, and two were application-level questions (e.g., inference, near transfer) intended to measure the quality of the student's situation model for that particular text. Fact-level questions asked questions that could be answered using information explicitly written in the text. On the other hand, application-level questions were less explicit requiring students to infer and apply information from the text. For example, a fact-level question for the text *Bacteria* read: "*Bacteria: a. have been used to reduce pollution, b. are used to create cheese. c. are used to create pharmaceuticals., d. All of the Above.*" Whereas, an application-level question would read: "*Strep throat, caused by a form of bacteria called streptococci, is a common bacterial infection. How can you cure strep throat? a. Get vaccinated., b. Avoid poultry and cattle. c. Take an antibiotic., d. There is no cure for a bacterial infection.*" Care was taken to ensure all questions targeted information found in the texts and was not presented in any other components of the experience. Comprehension was assessed in the post-test packet instead of immediately following each reading session in order to measure retention. Question reliability was confirmed for this sample using Cronbach's alpha ( $\alpha = .78$ ).

**Perceived Situational Interest.** A modified version of the Perceived Interest Scale (Schraw et al., 1995) was used to assess levels of perceived situational interest. The measure consists of 10 items measured on a 5-point Likert scale. Sample items include, “I thought today’s activity was very interesting”, and “I’d like to discuss Crystal Island with others at some point.” All factors have been shown to load on a single factor with a coefficient alpha of .83 (Schraw et al., 1995). Specific to this study, reliability of the Perceived Interest Scale was confirmed using Cronbach’s alpha ( $\alpha = .95$ ).

**Microbiology Content Knowledge.** The same 13-item content test described above was administered to assess learning gains.

**Overall experience.** Students in all conditions were asked to rank the degree to which they found specific features of the instruction interesting using a 5-point Likert scale. The survey was adapted for each condition. For example, students in the digital game-based learning condition were asked to the degree to which they found features such as the character interactions and the story line interesting; whereas, students in the PowerPoint condition were asked the degree to which they found “going at their own pace” and “working on the computer” interesting. A total of 8 features were assessed for the digital game-based learning condition, 7 for the classroom game-based learning condition, and 4 for the PowerPoint condition. All features are based on theoretical sources of situational interest—cognitive dissonance, meaningfulness, and interactivity (see Table 2.3). Also, using an open-ended question, students were asked to answer, “what would have made today’s activity more interesting?” Responses were coded and scored by trained raters using the proposed

coding scheme found in Appendix G. Inter-rater reliability was employed to ensure reliability ( $\alpha = .92$ ).

Following the experimental conditions, a small subset of students ( $N = 36$ ) was asked to participate in one-on-one, semi-structured interviews to triangulate and expand upon the quantitative data. Students were randomly selected. Sessions were conducted using the interview protocol found in Appendix D.

Interview questions serve to gather a phenomenological perspective and were written for two purposes: for students to elaborate on perceptions of situational interest and to identify specific aspects of the game or activity that lead to this interest. Students were asked to recount their experience and expand upon perceived levels of interest for the activity, reading passages, and microbiology. Students were encouraged to explain the conditions that fostered feelings of interest. Interview questions were written to specifically target those qualities hypothesized or shown in the literature to elicit situational interest; however, students were allowed to discuss beyond these constraints. Reliability and validity of the interviews were addressed by coding interviews twice using both thematic and data-driven techniques (DeCuir-Gunby, Marshall, & McCulloch, 2011) and employing inter-rater reliability ( $\alpha = .94$ ). The coding manual used for this analysis can be found in Appendix G.

## Procedure

Table 3.2

*Study Schedule*

Day	PowerPoint	Classroom-based Learning	Game-based Learning
Day 1 (Week Prior)	Pre-test	Pre-test	Pre-test
Day 2	Intro/ PowerPoint	Intro/ Activity Packet	Intro/Tutorial/ Play Game
Day 3	PowerPoint	Activity Packet	Play Game
Day 4	Post-test	Post-test	Post-test
Day 5	Interview	Interview	Interview

The entirety of the study took place over the course of five class periods (Table 3.2). On the first day, in the week leading up to the experiment, students completed the pre-test packet administered by their science teacher. Using a quasi-experimental design, students were then assigned as a class to one of three conditions: digital game-based learning ( $N = 60$ ), classroom game-based learning ( $N = 47$ ), or PowerPoint ( $N = 47$ ). A total of three classes were assigned to each condition. For a more detailed description of each condition, see Appendix E. Due to the constraints of school structure and the materials of the study, classes, as opposed to individual students, were randomly assigned to a condition.

**Digital game-based learning condition.** On the second day, students in the digital game-based learning condition viewed the two-minute introductory video described above and completed the tutorial level of CRYSTAL ISLAND: LOST INVESTIGATION. The tutorial level

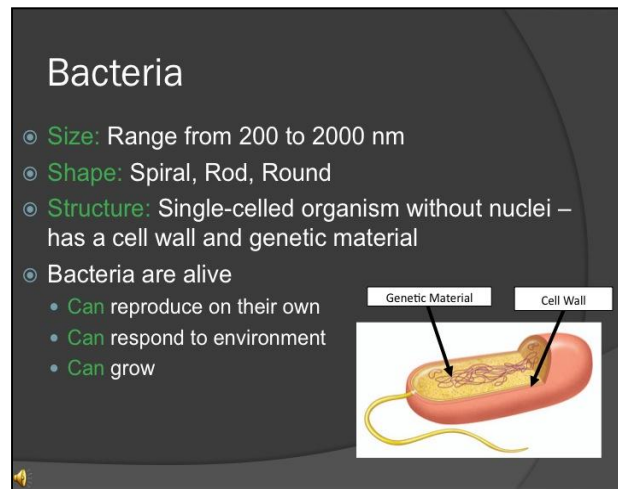
served to acquaint students to game controls and navigation in the environment and to ensure that students enter the game with an equitable level of game expertise. The tutorial was designed to take approximately 5-10 minutes. Upon successful completion of the tutorial, students began playing the actual game. Students were given a total of 80 minutes to complete the game. Class periods lasted 55 minutes and students were able to save their game progress and continue playing through Day 3. Students were free to read the seven expository texts in any order; however, texts were strategically placed to encourage reading order similar to that found in the two classroom-based conditions. Also, the game system required students to read all seven texts before attempting to submit a solution to the mystery. Researchers and the students' teacher were available to field any basic control questions during gameplay. No help was given for mission-based inquiries. Students were also asked to work independently and attempts for collaboration will be controlled. On the day following completion of the game, Day 4, students were asked to complete the post-test packet.

**Classroom game-based learning condition.** Participants in the classroom game-based condition were also allotted 80 minutes to complete the activity. Students were given a general overview of their assignment and then work independently to complete an activity packet and worksheet (Appendix E). The first sheet of the packet presented dialog from Kim, the camp nurse of Crystal Island, introducing the mission to the student. Then, students participated in four activities: read character sketches, gather information, test objects, and submit diagnosis. Between each activity, students were presented with a set of expository texts. All instructions, activity materials, and expository texts were provided in the packet;

furthermore, a paper-pencil replica of the diagnosis worksheet found in the CRYSTAL ISLAND: LOST INVESTIGATION environment was provided. Again, researchers and the students' teacher were available to field any instruction-related questions, but no help was given for mission-based inquiries. Students were also asked to work independently and attempts for collaboration were controlled. On the day following completion of the worksheet, Day 4, students were asked to complete the post-test packet. The purpose of this condition was to understand how aspects of the gaming environment (e.g., choice, interactivity, autonomy) affect situational interest and comprehension within a traditional classroom environment.

**PowerPoint condition.** The PowerPoint condition was intended to simulate more standard classroom conditions in order to better understand the hypothetical advantage of game-based and more inquiry-based classroom-based instruction. Similar to the other two conditions, students were given an overview of their assignment and then began interacting with the self-paced PowerPoint presentation (Figure 3.1). Students were given a paper-pencil, structured note-taking space for taking notes during the interaction (Appendix E); therefore, students in this condition were encouraged to take notes similar to those taken through the diagnosis worksheet found in the other two conditions. It should be noted, an exact copy of the diagnosis worksheet was deemed inappropriate given its association with the narrative embedded in the game-based. Students were given 80 minutes to complete the activity. Expository texts were appropriately embedded and grouped as they were in the classroom game-based condition. No instructor or researcher help was provided for students' material-

specific questions. On the day following this exercise, Day 4, students were asked to complete the post-test packet.



*Figure 3.1.* Example PowerPoint slide.

On the final day, Day 5, three trained interviewers interviewed selected students ( $N = 36$ ). Interviews followed the predefined semi-structured format and lasted approximately 3-4 minutes. Interviews were voice recorded and transcribed.

## CHAPTER FOUR

### Analysis

In this study, the impact of the three conditions on situational interest and text comprehension was analyzed using both quantitative and qualitative analysis: descriptive statistics (Table 4.1), Analysis of Covariance (ANCOVA), multilevel modeling, linear regression, and thematic coding. Specifically, key study variables were as follows: 1) *prior knowledge*, a sum score of students' performance on the microbiology content test administered in the pre-test packet, 2) *reading interest*, a summed, composite score consisting of pre-test ratings on the Motivations for Reading Questionnaire, ratings of self-efficacy for reading, and ratings of interest for reading, 3) *science interest*, a summed, composite score consisting of ratings of self-efficacy for science and microbiology, and ratings of interest for science and microbiology, 4) *reading ability*, a summed score of students' performance on the TORC-4 subtests for relational vocabulary and reading comprehension, 5) *reading comprehension*, a summed score of students' performance on the comprehension questions for each of the seven informational texts (divided into text- and application-level questions), and 6) *overall situational interest*, a composite score comprised of the five, Likert-scale ratings of situational interest following each of the seven informational texts. As seen in Table 4.2, bivariate correlations were conducted to provide a preliminary sketch of significant relationships between primary variables.

Table 4.1

*Overall Descriptive Statistics of Key Study Variables by Condition*

Study Variable	Minimum	Maximum	Mean (SD)
Prior Knowledge	1.00	12.00	6.14 (2.68)
Game-based	1.00	11.00	6.88 (2.44)
Classroom-based	2.00	11.00	5.91 (2.65)
PowerPoint	1.00	12.00	5.42 (2.87)
Reading Interest	34.00	113.00	82.39 (16.91)
Game-based	52.00	107.00	81.07 (14.85)
Classroom-based	34.00	113.00	84.09 (17.13)
PowerPoint	41.00	112.00	82.32 (17.45)
Science Interest	16.00	64.00	43.37 (9.46)
Game-based	30.00	62.00	43.39 (7.39)
Classroom-based	24.00	60.00	42.80 (10.51)
PowerPoint	16.00	64.00	44.00 (10.90)
Reading Ability	6.00	47.00	31.62 (8.56)
Game-based	14.00	46.00	32.67 (7.43)
Classroom-based	13.00	47.00	32.27 (8.27)
PowerPoint	6.00	46.00	44.00 (10.06)
Reading Comprehension	5.00	27.00	15.37 (5.44)
Game-based	5.00	27.00	16.04 (4.58)
Classroom-based	6.00	26.00	16.11 (5.22)
PowerPoint	5.00	26.00	13.72 (5.44)
Fact-Level	1.00	14.00	7.61 (2.98)
Game-based	2.00	13.00	7.88 (2.45)
Classroom-based	1.00	14.00	7.81 (3.02)
PowerPoint	1.00	14.00	7.05 (3.52)
Application-Level	1.00	14.00	7.76 (2.91)
Game-based	3.00	14.00	8.16 (2.54)
Classroom-based	2.00	13.00	8.30 (2.77)
PowerPoint	1.00	12.00	6.68 (3.26)
Overall Situational Interest	48.00	227.00	161.53 (33.29)
Game-based	118.00	227.00	172.95 (22.99)
Classroom-based	93.00	209.00	163.00 (33.17)
PowerPoint	48.00	218.00	145.18 (38.41)

Table 4.2

*Correlation Matrix of Key Study Variables*

Study Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Prior Knowledge	1						
(2) Reading Interest	.353**	1					
(3) Science Interest	.267**	.604**	1				
(4) Reading Ability	.633**	.364**	.156*	1			
(5) Reading Comprehension	.675**	.355**	.207**	.711**	1		
(6) Fact-Level	.584**	.293**	.160*	.651**	.914**	1	
(7) Application-Level	.647**	.355**	.219**	.644**	.908**	.660**	1
(8) Overall Situational Interest	.228**	.354**	.390**	.220**	.346**	.249**	.391**

Note: \* $p < .01$ , \*\* $p < .001$

Preliminary descriptive analyses were conducted in order to address any significant differences between students and conditions prior to the experimental manipulations. Relevant means can be found in Table 4.1. A series of one-way ANOVAs revealed conditions did not differ significantly in reading interest nor science interest. However, significant differences were found between students' reading ability scores ( $F_{(2, 253)} = 3.79$ ,  $p < .05$ ) and prior microbiology knowledge ( $F_{(2, 263)} = 6.31$ ,  $p < .01$ ). Tukey's post-hoc tests revealed significant differences between students' reading ability scores in the digital game-based learning condition and the PowerPoint condition ( $p < .05$ ); however, no other differences were found. With respect to prior microbiology knowledge, Tukey's post-hoc tests found significant differences between students in the digital game-based learning condition and the other two conditions (classroom game-based learning,  $p < .05$ ; PowerPoint,

$p < .01$ ), but no other differences were found. For this reason, these variables were controlled for in future analyses.

**Do digital game-based learning environments trigger and sustain greater levels of situational interest than classroom-based learning conditions?**

In order to evaluate how experimental manipulations affect levels of situational interest for eighth-grade students, several analyses were conducted. A one-way ANOVA found significant differences between conditions for overall situational interest ( $F_{(2, 145)} = 9.74, p < .001, \eta^2 = .12$ ). Tukey's post-hoc test found students in the digital game-based learning ( $M = 172.95, SD = 22.99$ ) and classroom game-based learning ( $M = 163.00, SD = 145.18$ ) conditions to be significantly more interested than students in the PowerPoint condition ( $M = 145.18, SD = 33.29$ ).

Furthermore, a series of ANCOVAs found significant differences in overall situational interest between conditions when controlling for certain variables hypothesized to affect levels of situational interest. As presented in Table 4.3, after adjusting for microbiology prior knowledge, the main effect of condition remained significant ( $F_{(2, 142)} = 7.24, p < .01, \eta^2 = .10$ ). Again, students in the digital game-based learning and classroom game-based learning conditions reported significantly higher levels of situational interest than students in the PowerPoint condition. No difference was found between students' situational interest in the game-based and classroom game-based learning conditions when controlling for prior content knowledge.

Similarly, after adjusting for reading ability, the main effect of condition remained significant ( $F_{(2, 142)} = 6.83, p < .01, \eta^2 = .10$ ). As before, students in the digital game-based learning and classroom game-based learning conditions reported significantly higher levels of situational interest than students in the PowerPoint condition. No difference was found between students' situational interest in the digital game-based and classroom game-based learning conditions when controlling for reading ability.

Table 4.3

*Means and Variance in Levels of Situational Interest by Condition*

	Game-Based <i>M(SD, SE)</i>	Classroom-Based <i>M(SD, SE)</i>	PowerPoint <i>M(SD, SE)</i>
Overall Situational Interest	172.95 (22.91) <sup>a</sup>	163.00 (33.17) <sup>a</sup>	145.06 (38.86) <sup>b</sup>
Covariate: prior knowledge	171.12 (4.18) <sup>a</sup>	163.73 (4.59) <sup>a</sup>	146.88 (4.80) <sup>b</sup>
Covariate: reading ability	172.18 (4.16) <sup>a</sup>	162.26 (4.67) <sup>a</sup>	148.02 (4.99) <sup>b</sup>

Note: <sup>a,b</sup> $p < .01$

Also, using the ratings of situational interest taken during the interaction, multilevel modeling (MLM) was used to determine whether situational interest is sustained over the course of the interaction by examining both within and between-student factors. With MLM, the effect of individual differences, such as prior knowledge and personal interest, and within-student differences, such as situational interest over time, can be considered in the same analysis (Raudenbush & Bryk, 2002). Furthermore, MLM is particularly useful for this

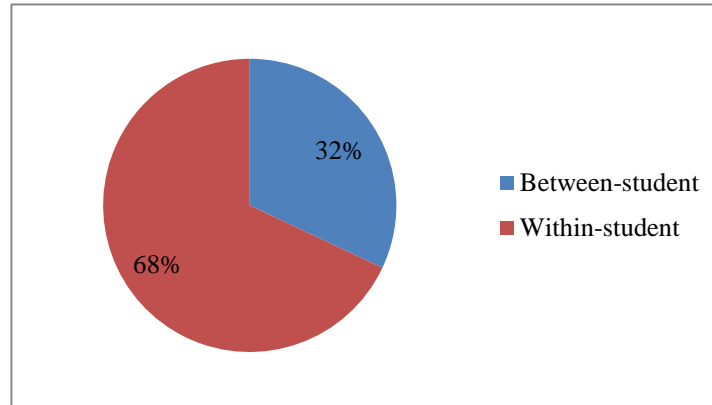
experiment as it can be used to analyze unbalanced data—or, cases with missing data points—without having to remove the entire case. Given the nested structure of the data (time within students) and the presence of missing data points, MLM was determined to be the most appropriate analysis for understanding the nature of students' situational interest over the course of the interaction. Specifically, several models were tested using situational interest as the dependent variable (*DV*) and the nested data structure time (Level 1) within students (Level 2):

A necessary first step in MLM analysis is partitioning the variance to determine whether there exists enough variance between and within students to continue with this method of analysis. To do so, the following two-level fully unconditional model was used:

$$\text{Level 1: } DV_{it} = \beta_{0i}t + \text{rit}$$

$$\text{Level 2: } \beta_{0i} = \gamma_{00} + u_{0i}$$

A total of 143 cases and 1570 observations were used for the analysis. As seen in Figure 4.1, the result of this analysis indicated a significant partition with 68% of the variance between students ( $\tau_{00} = 12.86$ ,  $z = 10.58$ ,  $p < .0001$ ) and 32% was within students ( $\sigma^2 = 4.63$ ,  $z = 25.64$ ,  $p < .0001$ ) with students reporting an average of 16.61 (maximum = 25) for situational interest. Therefore, the results of the model justified further analyses.



*Figure 4.1.* Between- and within-student partition of the variance.

In order to understand the nature of students' situational interest levels over the course of the interaction, the following one-way ANCOVA with random effects model was conducted:

$$\text{Level 1: } DV_{it} = \beta_{0it} + \beta_{1it}(\text{TIME}) + r_{it}$$

$$\text{Level 2: } \beta_{0i} = \gamma_{00} + u_{0i}$$

$$\beta_{1i} = \gamma_{10} + u_{1i}$$

Specifically, the model sought to answer the following questions: 1) On average, how do levels of situational interest fluctuate over time?, and 2) Do students vary in that change? On average, levels of situational interest did not significantly change over time ( $\gamma_{10} = -0.05$ ,  $t = -1.72$ ,  $p = .08$ ; Table 4.4).

Table 4.4

*Unstandardized Coefficients (and Standard Errors) of a Multilevel Model of Situational Interest*

Fixed Effects	Model 1
<b>Situational Interest, <math>\beta_0</math></b>	
Intercept, $\gamma_{00}$	16.80***(.023)
<b>Time slope, <math>\beta_1</math></b>	
Intercept, $\gamma_{10}$	-0.05(.03)
<b>Random Effects</b>	
Situational Interest ( $\tau_{00}$ )	10.82*** (1.27)
Interaction ( $\tau_{10}$ )	0.04(0.13)
Time slope ( $\tau_{11}$ )	0.11*** (.03)
Within-person fluctuation ( $\sigma^2$ )	4.09*** (0.18)

Note: \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

While students' interest does not appear to change over time on average, an intercepts and slopes as outcomes model was conducted in order to determine: 1) Does change in situational interest depend on condition?, 2) Do students vary in that change?, and 3) Is there a cross-level interaction? Specifically, the following model was entered into the analysis:

$$\begin{aligned} \text{Level 1: } DV_{ij} &= \beta_{0it} + \beta_{1it}(\text{TIME}) + r_{it} \\ \text{Level 2: } \beta_{0i} &= \gamma_{00} + \gamma_{01}(\text{Condition}) + u_{0i} \\ \beta_{1i} &= \gamma_{10} + \gamma_{11}(\text{Condition}) + u_{1i} \end{aligned}$$

As presented in Table 4.5, students in the digital game-based learning ( $\gamma_{01} = 3.52$ ,  $t = 6.59$ ,  $p < .0001$ ) and classroom game-based learning condition ( $\gamma_{02} = 2.91$ ,  $t = 5.40$ ,  $p < .0001$ ) reported significantly higher levels of situational interest than students in the PowerPoint condition. While there was no main effect of time, levels of situational interest

for students in the classroom game-based learning condition dropped significantly over time as compared to the PowerPoint students ( $\gamma_{11} = -0.29, t = -3.42, p < .001$ ). This finding indicates that although levels of situational interest for students in the PowerPoint condition were significantly lower than students' situational interest in the classroom game-based learning condition, changes in interest levels for the classroom game-based learning condition were not sustained over time as they were in the PowerPoint condition (Figure 4.2).

To compare levels of situational interest between students in the digital game-based learning condition and classroom game-based learning condition, dummy codes were created such that the average situational interest score for the classroom game-based learning condition was the intercept. Although no differences were found between levels of situational interest between the digital game-based learning condition and the classroom game-based learning condition ( $\gamma_{01} = 0.61, t = 1.17, p = 0.24$ ), there was an interaction with time. Over the course of the activity, students' levels of situational interest in the classroom game-based learning condition decreased significantly as compared to students in the digital game-based learning condition ( $\gamma_{11} = 0.17, t = 2.14, p < .05$ ). This finding indicates that although the digital game-based learning condition did not produce greater levels of situational interest, the game was successful at sustaining situational interest over the course of the entire interaction. The model accounted for 11% of the within-student variance and 33% of the between-student variance.

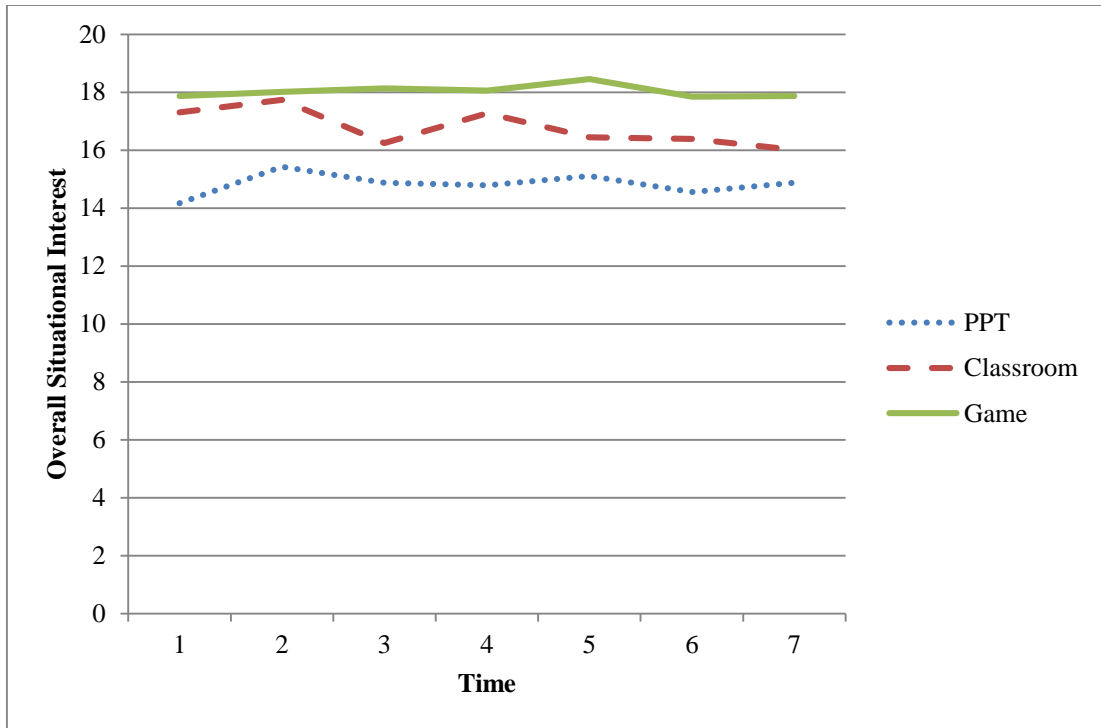


Figure 4.2. Levels of overall activity interest over time by condition.

Table 4.5

*Unstandardized Coefficients (and Standard Errors) of Multilevel Models of Situational Interest*

Fixed Effects	Model 1	Model 2
<b>Situational Interest, <math>\beta_0</math></b>		
Intercept, $\gamma_{00}$	14.57***(0.39)	17.48***(0.37)
Game-Based, $\gamma_{01}$	3.52***(0.53)	0.60(0.52)
Classroom-Based, $\gamma_{02}$	2.91***(0.53)	
PowerPoint, $\gamma_{03}$		-2.91**(0.54)
<b>Time slope, <math>\beta_1</math></b>		
Intercept, $\gamma_{10}$	-0.09(0.06)	-0.19**(0.06)
*Game-Based, $\gamma_{11}$	-0.11(0.08)	0.17*(0.08)
*Classroom-Based, $\gamma_{12}$	-0.28**(0.08)	
*PowerPoint, $\gamma_{13}$		0.28**(0.08)
<b>Random Effects</b>		
Situational Interest ( $\tau_{00}$ )	8.59***(1.07)	8.59***(1.07)
Interaction ( $\tau_{10}$ )	0.15(0.12)	0.15(0.12)
Time slope ( $\tau_{11}$ )	0.10***(0.03)	0.10***(0.03)
Within-person fluctuation ( $\sigma^2$ )	4.1***(0.17)	4.1***(0.17)

Note: \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Given previous findings suggesting prior knowledge and personal interests affects levels of situational interest (Schiefele, 1990; Schraw, 1995), additional multilevel modeling analyses were conducted and found similar results. Specifically, models controlling for the effect of prior knowledge and science interest found students in the game-based and classroom game-based learning conditions differed in situational interest fluctuation over time, and both groups reported significantly higher levels of situational interest than the PowerPoint students. A more detailed view of these analyses can be found in Appendix F.

Follow-up interviews with students from all three conditions further validate these findings. Interviews were given an overall rating of student activity interest by two trained coders as explained in the previous section. Similar to the quantitative findings, students in the game-based and classroom game-based learning conditions reported higher levels of interest than students in the PowerPoint condition. All interviews from students in the digital game-based learning condition ( $N = 10$ ) and classroom game-based learning condition ( $N = 9$ ) were rated as high activity interest. One student from the digital game-based learning condition reported, “Well, in [class], you usually just watch what she says and you learn, whereas if you're playing a game you kind of...you don't really know that you're learning it but in the end you really do learn it.” Another student stated, “Basically even the people who never do any work ended up doing the work inside of this.” Furthermore, a student from the classroom game-based learning condition stated, “It was very interesting because like mostly...most of the time when we do things, we don't do interactive types things.” However, students' ratings of activity interest in the PowerPoint condition ( $N = 8$ ) were less than unanimous. 4 students reported high levels of activity interest, 1 was moderately interested, and 3 did not like the activity. Students in this condition remarked that the activity would have been better if it had less reading and more interactivity, “like if it was a science experiment or something,” one student mentioned.

By triangulating the data from multiple quantities and qualitative sources, findings suggest both game-based and classroom game-based instructional methods were effective at generating higher levels of situational interest than learning from a simple PowerPoint

presentation. However, levels of situational interest were more stable over time for students in the digital game-based learning condition rather than the classroom game-based condition. Implications of this finding will be covered in the discussion.

**Does situational interest generated through digital game-based learning affect reading comprehension for texts embedded within the environment? Does situational interest predict reading comprehension above and beyond other variables?**

To assess the effect of experimental manipulations on expository text comprehension, a series of analyses were conducted. Comprehension for each of the seven texts by condition can be found in Table 4.6.

Table 4.6

*Passage Comprehension Means and Standard Deviations by Passage (Lexile Level)*

	<i>Scientific Method</i> (870L)	<i>How Do Diseases Spread?</i> (980L)	<i>Immunization</i> (1090L)	<i>Bacteria</i> (830L)	<i>Viruses</i> (910L)	<i>Salmonellas</i> (1000L)	<i>Influenza</i> (1100L)
Game-Based	2.44 (1.22)	2.45 (1.03)	1.11 (1.09)	2.34 (1.15)	1.80 (0.98)	2.48 (1.02)	2.70 (1.18)
Classroom-Based	2.48 (1.07)	2.36 (1.20)	1.20 (1.05)	2.02 (1.20)	1.89 (1.18)	1.98 (1.34)	2.22 (1.37)
PowerPoint	2.14 (1.20)	2.02 (1.26)	1.30 (1.14)	2.05 (1.17)	1.62 (1.04)	1.71 (1.36)	1.83 (1.35)
Total	2.36 (1.14)	2.29 (1.18)	1.20 (1.09)	2.15 (1.18)	1.78 (1.07)	2.08 (1.28)	2.28 (1.34)

With respect to between-condition effects (Table 4.7), significant differences in overall text comprehension were found using a series of ANCOVAs between conditions

when controlling for science interest ( $F_{(2, 142)} = 35.47, p < .05, \eta^2 = .12$ ), reading interest ( $F_{(2, 221)} = 3.89, p < .05, \eta^2 = .03$ ), and prior knowledge ( $F_{(2, 142)} = 4.27, p < .01, \eta^2 = .43$ ). For science interest, pairwise comparisons revealed the digital game-based learning students had higher comprehension at the application level than PowerPoint students ( $p < .05$ ); moreover, classroom game-based students performed significantly higher on the application level comprehension questions than the PowerPoint students ( $p < .05$ ). Pairwise comparisons between groups when controlling for reading interest revealed the same differences (respectively,  $p < .05, p < .05$ ). When controlling for prior knowledge, pairwise comparisons only determined the classroom game-based learning students performed significantly better on the application level comprehension questions than the PowerPoint students ( $p < .05$ ). No other differences were found. However, when controlling for reading ability, the main effect of condition was not significant. Furthermore, it is important to note, these findings must be interpreted with care as the assumption of homogeneity of variance was violated.

Table 4.7

*Means and Variance in Levels of Application-Level Comprehension by Condition*

	Game-Based <i>M(SE)</i>	Classroom-Based <i>M(SE)</i>	PowerPoint <i>M(SE)</i>
Application-level reading comprehension	7.79 (0.29) <sup>a</sup>	7.76 (0.35) <sup>a</sup>	6.44 (0.35) <sup>b</sup>
Covariate: science interest	7.75 (0.30) <sup>a</sup>	7.91 (0.35) <sup>a</sup>	6.56 (0.35) <sup>b</sup>
Covariate: reading interest	7.80 (0.28) <sup>a</sup>	7.74 (0.39) <sup>a</sup>	6.65 (0.39) <sup>b</sup>
Covariate: prior knowledge	7.42 (0.23) <sup>b</sup>	7.86 (0.27) <sup>a</sup>	6.89 (0.27) <sup>b</sup>
Covariate: reading ability	7.50 (0.22)	7.57 (0.27)	7.19 (0.27)

Note: <sup>a,b</sup> $p < .01$

Given the homoscedacity of the variance around comprehension, regression analyses were employed. A hierarchical linear regression was conducted with the entire sample entering science interest, reading interest, prior knowledge, and reading ability into the first block and overall situational interest into the second block with comprehension at the application level as the dependent variable (Table 4.8). For application-level comprehension, the first model was found to be significant ( $F_{(4, 138)} = 40.86, p < .001, \eta^2 = .54$ ) with prior knowledge ( $t = 4.35, p < .001$ ) and reading ability ( $t = 5.03, p < .001$ ) found to be the only significant predictors. The second model was also significant ( $F_{(5, 137)} = 37.08, p < .001, \eta^2 = .58$ ) with overall situational interest ( $t = 3.30, p < .01$ ), prior knowledge ( $t = 4.35, p < .001$ ), and reading ability ( $t = 4.91, p < .001$ ) found to be significant predictors.

Table 4.8

*Hierarchical Linear Regression Predicting Comprehension at the Level of the Situation Model for All Conditions*

Predictor	Model 1				Model 2			
	B	SE	$\beta$	t	B	SE	$\beta$	t
Reading ability	.14	.03	.41	5.03**	.13	.03	.39	4.91**
Prior Knowledge	.44	.10	.35	4.25**	.43	.10	.35	4.35**
Science Interest	-.02	.02	-.06	-.81	-.03	.02	-.11	-1.60
Reading Interest	.02	.01	.11	1.46	.01	.01	.07	0.99
Situational Interest					.02	.01	.20	3.26*

Note: \* $p < .01$ , \*\* $p < .001$

Interestingly, for textbase comprehension, the first model was found to be significant ( $F_{(4, 138)} = 33.19, p < .001, \eta^2 = .49$ ) with prior knowledge ( $t = 2.81, p < .01$ ) and reading

ability ( $t = 5.56, p < .001$ ) found to be the only significant predictors (Table 4.9). While the second model was also significant ( $F_{(5, 137)} = 26.84, p < .001, \eta^2 = .49$ ), only prior knowledge ( $t = 2.81, p < .01$ ), and reading ability ( $t = 5.45, p < .001$ ) were found to be significant predictors, not situational interest. Therefore, the data from this study aligns with previous research that has found situational interest only predicts comprehension at the level of the situation model, not the textbase (Schifele, 1990).

Table 4.9

*Hierarchical Regression Predicting Comprehension at the Level of the Textbase for All Conditions*

Predictor	Model 1				Model 2			
	B	SE	$\beta$	t	B	SE	$\beta$	t
Reading ability	.17	.03	.48	5.56**	.16	.03	.48	5.45**
Prior Knowledge	.31	.11	.24	2.81**	.31	.11	.24	2.80*
Science Interest	-.02	.02	-.07	-.94	-.03	.02	-.09	-1.19
Reading Interest	.02	.01	.09	1.22	.02	.01	.08	1.03
Situational Interest					.01	.01	.08	1.12

Note: \* $p < .01$ , \*\* $p < .001$

Moreover, when conducting the same analyses within each condition, meaningful differences transpire. Considering only the digital game-based learning condition, a hierarchical linear regression predicting application-level comprehension using reading ability, prior knowledge, science interest, reading interest, and situational interest as predictors was found to be significant ( $F_{(5, 55)} = 25.28, p < .001$ ) and explained 35% of the variance. Interestingly, for this group, prior knowledge was found to be the only significant

predictor of application-level comprehension (Table 4.10). Using the same analysis and predictors similar results were found when predicting fact-level comprehension ( $F_{(5, 55)} = 6.57, p < .001, \eta^2 = .34$ ); here, reading ability was identified as the only significant predictor.

For the classroom game-based condition, the hierarchical regression predicting application-level comprehension was significant overall ( $F_{(5, 44)} = 16.72, p < .001$ ) and predicted 68% of the variance (Table 4.10). However, for this condition, reading ability, prior knowledge, and situational interest were all found to be significant predictors. For fact-level comprehension, the model again was significant ( $F_{(5, 44)} = 7.73, p < .001, \eta^2 = .50$ ), but only prior knowledge significantly predicted comprehension.

Finally, when predicting application-level comprehension for the PowerPoint condition, the overall model was significant ( $F_{(5, 39)} = 21.10, p < .001$ ), and explained 76% of the variance (Table 4.10). In this group, reading ability, prior knowledge, science interest, and situational interest all significantly predicted comprehension. When predicting fact-level comprehension, the model was also significant ( $F_{(5, 39)} = 10.41, p < .001, \eta^2 = .61$ ), but reading ability was the only significant predictor.

Table 4.10

*Hierarchical Regression Predicting Comprehension at the Level of the Situation Model by Condition*

Predictor	Model 1				Model 2			
	B	SE	$\beta$	t	B	SE	$\beta$	t
<b>Game-Based Learning</b>								
Reading ability	.09	.06	.29	1.77*	.10	.06	.30	1.85*
Prior Knowledge	.32	.19	.26	1.72	.31	.19	.25	1.66
Science Interest	.01	.05	.03	.18	.02	.50	.05	3.62
Reading Interest	.02	.02	.10	.69	.02	.03	.10	.70
Situational Interest					-.01	.01	-.11	-.94
<b>Classroom-Based Learning</b>								
Reading ability	.12	.06	.37	2.03**	.09	.05	.28	1.73*
Prior Knowledge	.43	.19	.37	2.22**	.53	.17	.46	3.16**
Science Interest	-.01	.03	-.03	-.28	-.04	.03	-.15	-1.44
Reading Interest	.02	.02	.11	.85	.01	.02	.06	.50
Situational Interest					.03	.01	.39	3.83***
<b>PowerPoint</b>								
Reading ability	.14	.04	.43	3.62***	.14	.04	.43	3.84***
Prior Knowledge	.66	.17	.49	3.80***	.64	.16	.48	3.99***
Science Interest	-.06	.04	-.20	-1.45	-.11	.04	-.35	-2.43
Reading Interest	.04	.03	.22	1.59	.02	.03	.12	.94
Situational Interest					.03	.01	.31	2.49**

Note: \*  $p < .1$ , \*\*  $p < .05$ , \*\*\*  $p < .01$

While students in each group did not significantly differ in levels of reading comprehension, this finding could be explained by the heterogeneity of variance in situational interest and reading comprehension between groups. According to the regression analysis, it appears situational interest only affected application-level reading comprehension for students in the classroom game-based and PowerPoint learning conditions—conditions with greater variance and fluctuation in levels of situational interest over the course of the

interaction. In other words, it seems students in the digital game-based learning condition did not vary in their levels of situational interest making it a non-significant predictor of comprehension for this group. Therefore, within-groups, the effect of situational interest on application-level comprehension behaved as predicted by related literature (Schiefele, 1990; Schraw, 1995). However, differences in reading ability due to classroom effects, the heterogeneity of variance between groups for comprehension and situational interest, and the lack of expected manipulation effects cloud the validity of this analysis and are identified as a limitation of this work.

### **What components of digital game-based learning environments lead to greater levels of situational interest?**

By aggregating and triangulating students' Likert-scale ratings for sources of interest (quantitative,  $N = 227$ ), follow-up interviews (qualitative,  $N = 27$ ), and open-ended responses to the question, "what would have made Crystal Island more interesting" (qualitative,  $N = 145$ ), analyses were conducted in order to identify the specific features of students' experiences that generated perceptions of interest.

Using research-based sources of situational interest, students in each condition were asked to rank the degree to which certain aspects of the activity added to their interest on a 5-point Likert scale. As seen in Figure 4.3, students in the digital game-based learning condition identified being in the immersive 3D gameworld (novelty, interactivity;  $M = 4.20$ ,  $SD = 1.02$ ), making their own choices (autonomy;  $M = 4.18$ ,  $SD = 0.92$ ), and the mystery (narrative, challenge;  $M = 4.07$ ,  $SD = 1.06$ ) as adding to their interest more than talking to

characters (social interaction;  $M = 3.49$ ,  $SD = 1.19$ ), reading texts ( $M = 3.18$ ,  $SD = 1.19$ ), and taking notes ( $M = 3.06$ ,  $SD = 1.25$ ). Similarly, students in the classroom game-based learning condition reported the mystery (narrative;  $M = 3.61$ ,  $SD = 1.15$ ), testing objects (interactivity;  $M = 3.69$ ,  $SD = 1.03$ ), doing a hands-on activity (interactivity,  $M = 3.52$ ,  $SD = 1.05$ ), and making their own choices (autonomy;  $M = 3.75$ ,  $SD = 1.11$ ) contributed to their interest more than reading the texts ( $M = 3.01$ ,  $SD = 1.13$ ) and taking notes ( $M = 3.12$ ,  $SD = 1.25$ ). Lastly, students in the PowerPoint condition enjoyed going at their own pace (autonomy;  $M = 3.34$ ,  $SD = 1.21$ ) more than learning from PowerPoint slides ( $M = 3.00$ ,  $SD = 1.13$ ), taking notes ( $M = 2.79$ ,  $SD = 1.20$ ), and reading the texts ( $M = 2.80$ ,  $SD = 1.25$ ).

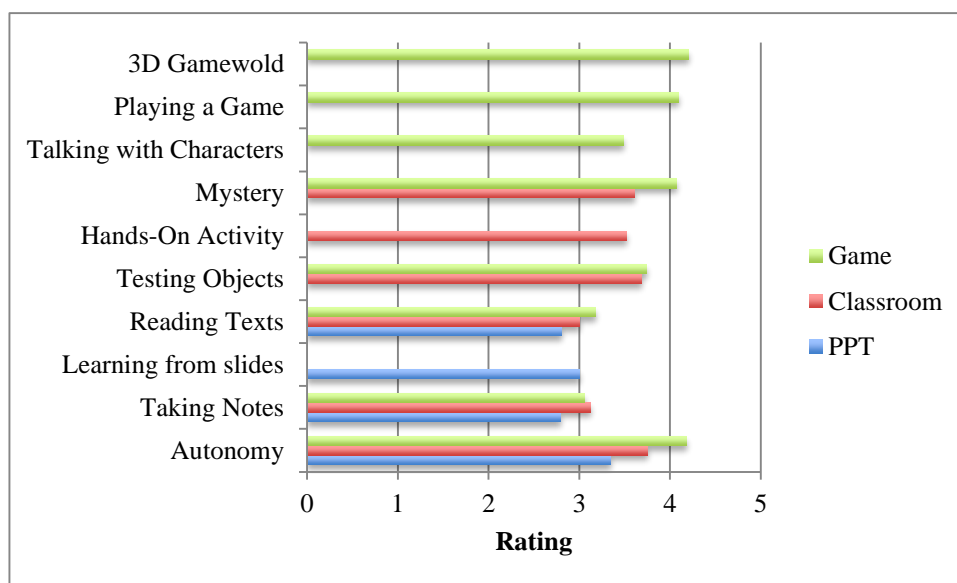
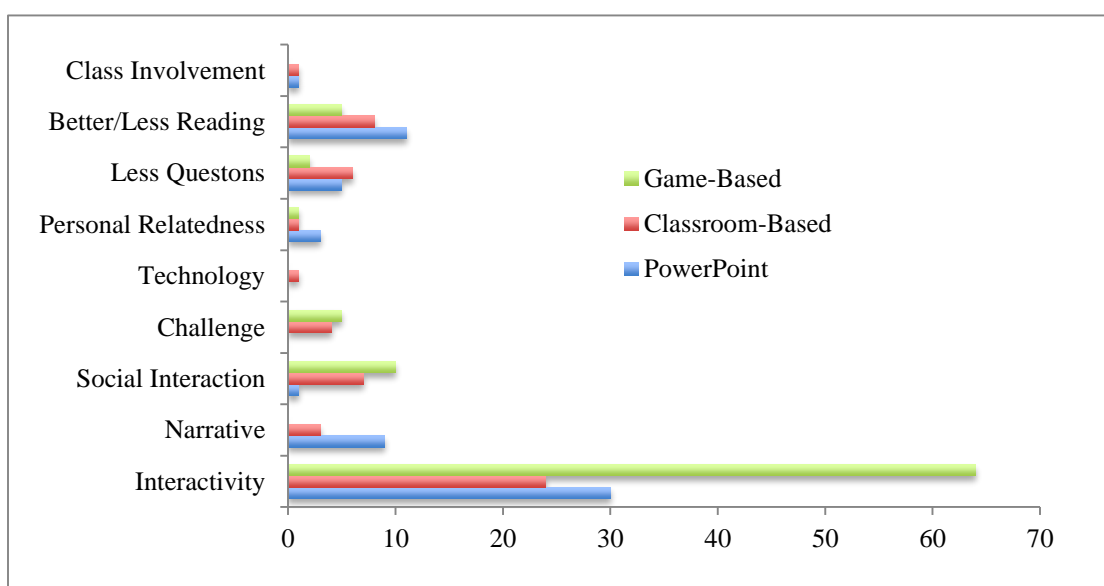


Figure 4.3. Student ratings for sources of situational interest.

In order to expand upon and triangulate the quantitative findings, the above qualitative analysis was compared to students' responses to the question, "what would have made the activity more interesting?" Responses were dichotomously coded by two trained researchers for mentioning research-based sources of interest (Table 2.3) as well as those specific to digital game-based learning environments. After cleaning the data for missing or irrelevant answers, 69 responses from the digital game-based learning condition, 35 responses from the classroom game-based learning condition, and 41 responses from the PowerPoint condition were used for the analysis.

As seen in Figure 4.4, for all conditions, the most common suggestions stemmed from features related to interactivity such as adding a game, using the iPads, or adding more in-game activities or abilities. In sum, there were 64 mentions of wanting more interactivity in the digital game-based learning condition, 24 in the classroom game-based learning condition, and 30 in the PowerPoint condition. A student in the PowerPoint condition noted, "Rather than making students read over and answer questions by themselves, consider doing something more interactive. That would catch the attention of younger students more. Every day we watch [PowerPoints], read texts and answer questions. Try to do something...that is unusual." Similarly, a digital game-based learning student suggested, "I think Crystal Island could've been a little more interesting if we had a bigger world to explore and if the books had a little less text in them. I think the "bigger world" aspect would make the game more interesting because I, personally, like to explore huge environments in the games. If the books had a little less text in them, I think I would've been a little more focused." Overall, it

appeared students in game-based and classroom game-based conditions wanted to extend rather than reduce their experience with 9 students explicitly suggesting more challenge, 36 wanting more abilities, goals, and sub-activities, and 28 wishing for a larger island to explore.



*Figure 4.4.* Student suggestions to what would have made the experience better.

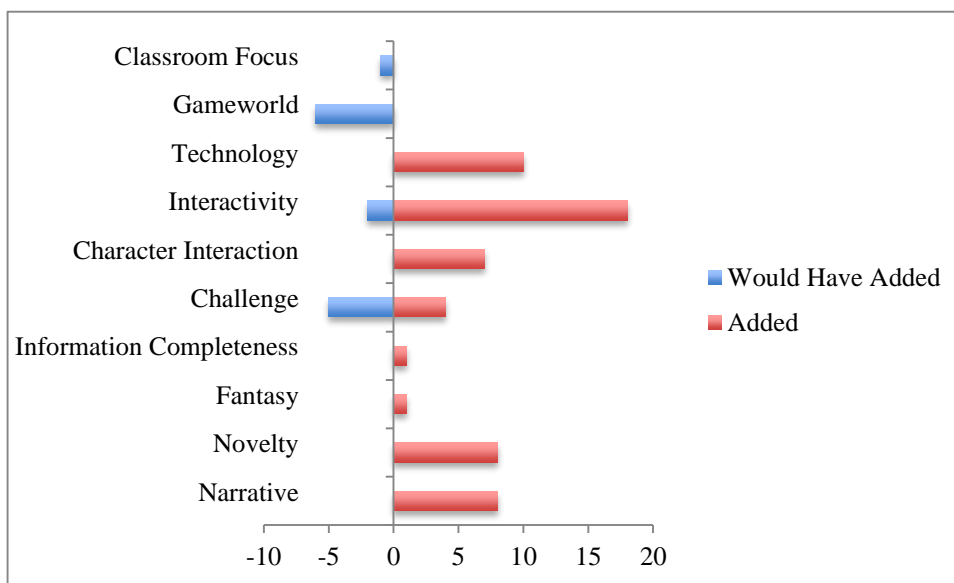
Interestingly, although several students mentioned they would have enjoyed the experience more with less reading passages ( $N = 13$ ), students in the game-based ( $N = 4$ ) and the classroom game-based learning conditions ( $N = 7$ ) suggested they would like to have received more text in the form of dialog from the characters. For example, a classroom game-based learning student said she would like “More reading passages about what the people at Crystal Island experienced.” Therefore, it seems texts more deeply embedded within the

narrative might generate greater levels of situational interest than the current implementation of expository text. Further implications of this suggestion will be delineated in the discussion.

Finally, the follow-up interviews corroborate these findings. As Figures 4.5-4.7 suggest, the most common comments were related to the degree of interactivity provided by the activity. Students in the game-based and classroom game-based conditions made several statements about how the interactivity of the activity added to their interest (respectively, 18 comments and 15 comments). Among statements classified as interactivity were those related to testing objects, running around the gameworld, filling out the diagnosis worksheet, and more general statements such as the “hands-on” nature of the activity. For example, one student in the digital game-based learning condition stated, “It was fun. I really, really liked how we got to test each food to see which one had a virus and stuff.”

Students in both the game-based and classroom game-based conditions also made several comments about the narrative (or mystery) aspect of the experience. A digital game-based learning student said, “I really enjoyed the activity because it...um, it kept me thinking and it was really interesting because I was wondering where the virus came from and if it wasn't a virus maybe...but then I went home and was thinking maybe it's not even the flu; maybe it's the water that's getting them sick because they're getting water supply from somewhere off the island.” Likewise, a classroom game-based student appreciated the nature of the activity since they “usually don't do stories in science.”

Students' preference for interactive, hands-on activities was also evidenced by interviews from students in the PowerPoint condition. While some students said the autonomy provided by the activity added to their interest, students more commonly made remarks about what *would have made* the experience more enjoyable. Again, these students demonstrated a desire for interactivity and technology-based activities. For example, one student commented, "I would rather do the activity again with like a science project like an experiment of some sort... Like hands-on experiments where like you get to mix this and this together and this will happen."



*Figure 4.5.* Reported sources and potential sources of situational interest for students in the digital game-based learning condition

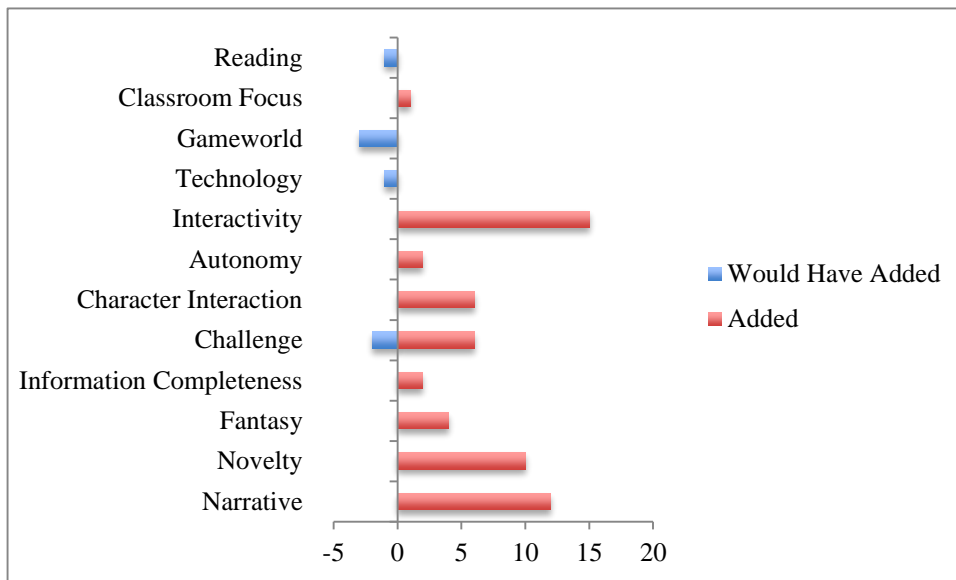


Figure 4.6. Reported sources and potential sources of situational interest for students in the classroom game-based learning condition.

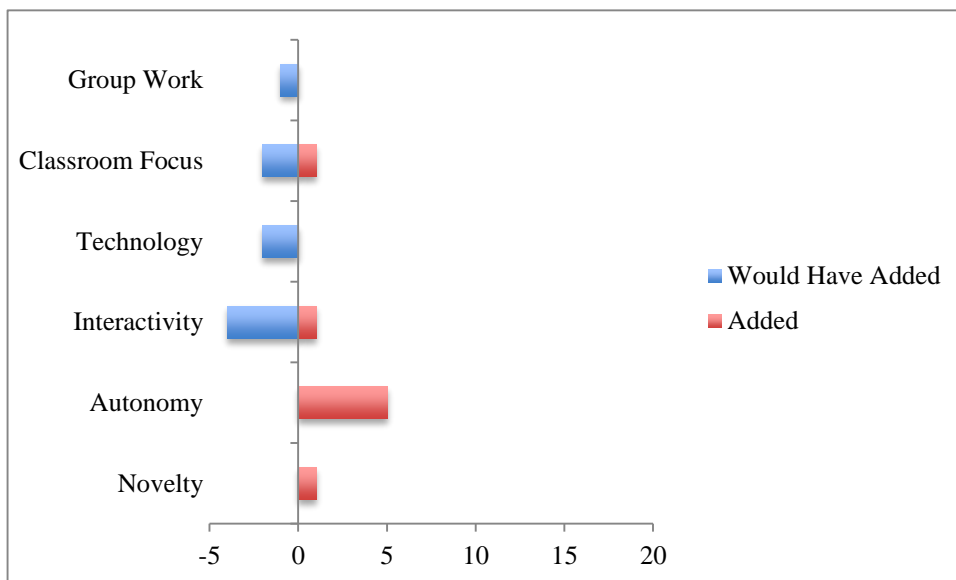


Figure 4.7. Reported sources and potential sources of situational interest for students in the PowerPoint condition.

In sum, the qualitative and quantitative data sources converged supporting the previous findings that students in the more interactive, immersive game-based and classroom game-based learning conditions experienced greater levels of situational interest than students in the PowerPoint condition. Specifically, students explicitly identified aspects related to the underlying narrative (e.g., solving the mystery), features that allowed for direct manipulations (e.g., testing objects), and social interaction (e.g., speaking to characters/reading character dialog) as particularly interesting. Activity components less integrated within the narrative such as the expository texts contributed less to the students' interest; therefore, an important area of future research lies in manipulating the degree to which expository texts are embedded within the narrative. Further discussion of this implication will follow.

## CHAPTER FIVE

### Discussion

Little research has been devoted to investigations concerning the effect of situational interest elicited by a learning environment (e.g., digital game-based learning environments) on comprehension (Guthrie, et al., 2006). The purpose of this study was three-fold: 1) to determine whether CRYSTAL ISLAND: LOST INVESTIGATION, a digital game-based learning environment for microbiology, generates and sustains levels situational interest greater than those generated through classroom-based instructional methods, 2) to determine whether the situational interest generated by digital game-based learning environments affects levels of reading comprehension for expository texts, and 3) identify a set of digital game-based learning features particularly instrumental in the manifestation of situational interest. Overall, CRYSTAL ISLAND: LOST INVESTIGATION, was found to be an effective tool for *generating and sustaining* levels of student situational interest compared to classroom-based conditions. Specifically, the digital game-based learning condition was compared to a paper-pencil, classroom-based learning environment that replicated some of the known sources of situational interest present in the game (e.g., narrative, social interaction) while omitting others such as interactivity and technology. The purpose of this condition was to represent an active classroom lesson that does not require technology or a software investment in order to better understand the value of educational games in this context. Also, the digital game-based learning condition was compared to a PowerPoint-based lesson intended to replicate

common, lecture-style instruction that incorporates far fewer sources of situational interest (i.e., narrative, interactivity, social interaction).

As a result, students interacting with the game-based learning conditions reported greater levels of situational interest than students asked to complete a PowerPoint-based lesson. Moreover, students in the CRYSTAL ISLAND condition reported less fluctuation in levels of situational interest than students engaging in the paper-pencil, classroom-based version of the game environment, a critical difference according to the theoretical framework supporting the psychological effects of situational interest. This finding supports prior research (Hidi & Renninger, 2002; Mitchell, 1993) that portrays situational interest as a temporary state of cognitive arousal contingent upon both internal and external factors. The positive effect situational interest has on cognitive processing is partly dependent upon environment's ability to *sustain* the state over time. In this work, students in the digital game-based learning condition reported high levels of situational interest throughout the course of the interaction. Comparatively, students' situational interest in the classroom game-based learning condition appeared to fluctuate over time indicating potential periods of reduced cognitive and affective arousal. Therefore, these findings support the use of interactive, digital game-based learning environments as an effective instructional method for both generating *and* sustaining levels of situational interest even for students previously uninterested in the targeted topic.

With respect to the effect of situational interest on reading comprehension, this study replicates the findings of several text- and classroom-based studies (Schiefele, 1990; Schraw,

1995; Rotgans & Schmidt, 2012) within a digital game-based learning environment. Overall, students experiencing greater levels of situational interest performed significantly better on application-level comprehension questions—questions targeting comprehension at the level of the situational model—than those reporting lower levels of situational interest even when controlling for prior knowledge, reading ability, and personal interest. Therefore, as hypothesized, students experiencing greater levels of situational interest experienced heightened levels of cognitive activity and engaged more deeply with the texts than students reporting lower levels of situational interest. As commonly found in previous investigations, this finding was not replicated for those questions measuring comprehension at the level of the textbase (Schiefele, 1990; Schraw, 1995).

Moreover, proponents of the digital game-based learning movement argue that the power of games lie in their ability to appeal to students inherent interests in challenge, novelty, fantasy, clear objectives, and interactivity (Gee, 2007), which significantly overlap with research pertaining to factors affecting levels of situational interest. However, previous digital game-based learning investigations have not directly verified these assumptions. The current study employed a mixed-methods technique that included post-experiment interviews and quantitative rankings to pinpoint the hypothesized sources of interest and to 1) confirm the validity of several aspects of games as sources of situational interest, and 2) support the connections drawn between the situational interest literature and the gaming literature.

Students attributed levels of situational interest to the underlying narrative (e.g., solving the mystery), features that allowed for direct manipulations (e.g., testing objects), and

social interaction (e.g., speaking to characters/reading character dialog)—all of which are consistent with previous situational interest investigations (Bergin, 1999; Schraw, 1995; Mitchell, 1993). In contrast, non-narrative and non-interactive features of their lesson were identified as elements that took away from the experience. Therefore, embedding interactive activities and content-based simulations that direct students' attention toward the targeted material appears to appeal to students' interests without necessarily utilizing seductive details.

### **Implications for Educators**

Although CRYSTAL ISLAND: LOST INVESTIGATION was superior for both triggering and sustaining levels of situational interest, these results should be interpreted carefully until additional research can be completed. Given the relatively similar levels of situational interest produced by the digital and classroom game-based learning conditions, devising classroom-based activities, such as the one used in this study, could be a reasonable substitute when resources and budgets are limited. However, when developing such an activity, results of this study do suggest incorporating known sources of situational interest purposefully in order to promote engagement for the to-be-learned topic as opposed to extraneous details.

Given the predictive power of situational interest for reading comprehension (Schraw, 1997; Renninger & Hidi, 2011; Schiefele, 1999), the findings of this study are especially relevant for those educators working to incorporate the additional focus on informational texts mandated by the newly adopted Common Core State Standards. As evidenced by

previous research (Wade, et al., 1999; Hidi & Baird, 1986), readers tend to comprehend information that is both important *and* interesting significantly better than information that is *either* important *or* interesting. Within this context, responses from the qualitative component of this work found students were more likely to report mission-related—those activities specifically relating to the embedded content—aspects of the experience as adding to their interest. Furthermore, when asked to expand upon what would have made the experience more enjoyable, students in the game-based learning conditions often pointed to features that would expand, as opposed to reduce, their interaction with the targeted curriculum. Moreover, for students in all three experimental conditions, situational interest was found to be a significant predictor of reading comprehension for the embedded informational texts above and beyond motivation for reading, personal interest in science and/or reading, reading ability, and prior knowledge. In sum, although constraints of the classroom might limit one's ability to introduce sources of situational interest, carefully embedding informational texts within an activity devised to promote interest for the targeted material could produce similar benefits for reading comprehension as seen in this work.

### **Implications for Educational Game Designers**

The cross-disciplinary and mixed-methods nature of this research exposed important implications for the developers of educational games. First, the substantial overlap between features of games contributed with “why games work” and the known sources of situational interest uncovers a potential area for collaboration between these two fields. To date, the digital game-based learning movement has been met with great opposition as the majority of

research has yet to report many significant, positive learning effects (Adams et al., 2010; Mayer & Johnson, 2012). However, this relatively new area currently lacks a sound, widely-adopted theoretical framework (Mayer & Johnson, 2012), and a recent analysis of the literature suggests games are more often evaluated in terms of learning gains alone (Alifieri et al., 2013). However, the few published studies that have evaluated game-based learning environments based on factors relevant to situational interest, such as cognitive processing (Mayer, 2010) and narrative (Barab, et al., 2012), have found results in favor of this instructional method.

Therefore, in light of these results and the findings found in this report, situational interest appears to be a viable design and evaluation tool for educational game developers going forward. Namely, the substantial body of situational interest literature serves to generalize the game-based learning community's approach to design and evaluation by providing established models of related constructs and processes (e.g., Hidi & Renninger, 2002). By adhering to the theoretical frameworks of situational interest, student engagement should be generated through game elements that promote cognitive and affective processing for the targeted material as opposed to more orthogonal details.

### **Notable Limitations**

As with many empirical investigations, the proposed study suffers from certain limitations. First, this work only employs one digital game-based learning environment, CRYSTAL ISLAND: LOST INVESTIGATION, one domain, microbiology, and one grade level, 8<sup>th</sup> grade. Therefore, generalizations of the findings to other learning scenarios must be made

with care. It is not clear that the effects of the environment (e.g., interactivity, narrative) on situational interest were due to general gaming characteristics that can be replicated in other gaming environments. Also, the specific game components found to be instrumental in developing situational interest might not be applicable to other environments. However, features present in the CRYSTAL ISLAND environment such as running contaminations tests and speaking with characters—both of which were attributed to increasing levels of situational interest—have been found in other learning environments (Baker & Clarke-Midura, 2013). In fact, work by Baker and colleagues (2013) found both of these features, running tests and speaking with characters, as valuable behaviors for increasing game performance. Nonetheless, the magnitude of this study's implications hinges upon the generalizability of influential game characteristics. Similarly, the findings of this study have not been tested with informational texts and scenarios beyond the domain of microbiology or with students at other grade levels. Although previous work suggests the effect of situational interest on comprehension is consistent across ages (Renninger & Hidi, 2011), it cannot be assumed the results found in this study generalize to other grade levels. Therefore, an important next step would be to replicate the methods used in the current investigation using different environments, domains, and populations.

Also, the findings of this study rely on the assumption that the digital game-based learning and classroom game-based learning conditions differed in terms of interactivity and were otherwise analogous for other sources of situational interest. Although great lengths were taken to control for certain features across the conditions, the nature of situational

interest makes it difficult to measure whether specific sources of situational interest designed to be equal across conditions (i.e., narrative, relevancy) were indeed perceived that way by the students. Furthermore, observational reports suggest the majority of students in the digital game-based learning condition were quiet and working independently. However, without headphones and a computer, students in the classroom game-based learning condition were more likely to talk amongst themselves and collaborate on the learning task, which might have inappropriately introduced sources of situational interest such as social interaction. Finally, given the ecological constraints of this school-based study, systematically tracking time on task was relatively impossible. Although all students were allotted the same amount of time to complete their condition-specific exercises, it cannot be confirmed that students experienced equal time on task; thus, variance in performance on various outcome measures could be attributed to additional or a lack of time on task. To address this limitation, the tasks could be deconstructed further and different elements could be controlled across conditions to avoid this limitation.

Also, due to sampling constraints it is unclear whether classroom effects influenced the findings. Notably, between-condition effects for reading ability were unfortunately present as students in the PowerPoint condition reported significantly lower levels for this metric. Although such effects were taken into consideration during the main analyses, it is uncertain whether other classroom effects were present that could have confounded the results. Also, as the study was conducted over multiple days, it can be reasonably assumed that students in all three conditions discussed their experience outside of class. Consequently,

it is not clear whether this knowledge affected students' responses during the qualitative phase of the data collection. For example, students in the PowerPoint condition often referenced games as a potential solution for increasing student interest in the activity. Therefore, the extent to which this stance was conceived on their own or through awareness of the game-based learning condition is unclear. Study conditions more conducive to random assignment of students while maintaining ecological validity should be used in future work.

Furthermore, the hypothetical nature of situational interest implies certain degree of measurement error and generalizability difficulties. Debate around how situational interest should be defined and unobservable effects of its manifestation impede the development of a reliable and valid method for measurement. Despite attempts for multiple methods and triangulation, the accuracy of the approximations of situational interest levels cannot be guaranteed. Moreover, as researchers define situational interest differently, only when the construct is defined in line with the definitions within this work can the findings be generalized to similar studies and the methods be utilized in future work.

### **Future Work**

Aside from conducting similar studies designed to address the above limitations, the implications of this study present new challenges for future research. Given that findings from the current investigation suggest that situational interest elicited by the learning task is positively associated with reading comprehension, an interesting next step would be to analyze how to further enhance these results within digital game-based learning environments. In the current investigation, informational texts were presented simply as

problem-solving resources and were not necessarily “mission-critical” for solving the CRYSTAL ISLAND mystery. In other words, all information necessary for solving the mystery could be found through other venues and actions within the environment. Perhaps including only including text that is integral for solving the embedded mystery would generate greater feelings of relevance and importance. In the current study, it was not guaranteed that each student read each text thoroughly and purposefully. By modifying the narrative and/or varying the degree to which the texts included such mission-critical information, it is likely the degree of situational interest would increase given the added relevancy for the student.

Additionally, the positive associations between situational interest, digital game-based learning, and reading comprehension highlighted by this work provides several opportunities for leveraging features such as logging students’ in-game actions for measuring and automatically enhancing the digital game-based learning experience for individual students. First, triangulating self-report measures with in-game actions could provide a first step for creating real-time metrics for situational interest that do not require the use of self-reports. Consequently, by utilizing artificial intelligence modeling techniques, digital game-based learning experiences could be designed to adapt to students based on both personal and situational factors as outlined in Figure 2.1 in order to optimize levels of situational interest.

The purpose of this study was to not only expand upon the situational interest and digital game-based learning research but also investigate parallels between two bodies of literature. The findings serve to encourage gaming researchers to use situational interest as a lens for designing and evaluating systems. Without interest, games are no more engaging

than a traditional classroom lecture and it cannot be assumed students will become situationally interested simply because the environment is called “a game.” Conversely, game features must be added and integrated with care so not to interest the student in superfluous features as opposed to the target material (Garner et al., 1992). A great deal of future work must be done in order to discover how to best balance game features and develop effective digital game-based learning environments for instructional purposes.

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APPENDICES

Appendix A  
Relevant Instruments

Demographic Survey

1. How old are you?
2. What is your ethnicity?
3. What is your gender?

Science, Reading, and Gaming Interest

<b>Really Dislike</b>	<b>Dislike a little</b>	<b>Neither like nor dislike</b>	<b>Like a little</b>	<b>Really like</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

How do you feel about the following?

1. Science
2. Reading
3. Videogames

<b>Not at all</b>				<b>A lot</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

How much do you value learning about the following?

1. Science
2. Reading
3. Videogames

<b>Not very good</b>				<b>Very good</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

How good are you at the following?

1. Science
2. Reading
3. Videogames

Reading and Science Interest Questionnaire

(1. Strongly Disagree, 2. Disagree, 3. Neither Agree Nor Disagree, 4. Agree, 5. Strongly Agree)

1. I enjoy playing videogames more than other activities.
2. Videogames are interesting to me.
3. I enjoy all types of videogames.
4. I enjoy reading more than other activities.
5. Reading is interesting to me.
6. I am not interested in the things I read at school.

Self-Efficacy Items (name not to be displayed to students):

(1. Strongly Disagree, 2. Disagree, 3. Neither Agree Nor Disagree, 4. Agree, 5. Strongly Agree)

1. I am sure that I can learn about microbiology.
2. It will be difficult for me to learn microbiology.
3. I feel confident that I will be able to learn about microbiology in science.
4. Learning about microbiology in science will be easy for me.
5. I am certain that I can master any videogame I play.

6. Even when I try hard, I don't do well at playing videogames.
7. I can do well at even the most challenging videogame.
8. Even when I try hard, learning how to play a new videogame is complicated for me.
9. I am sure that I can read texts in my science classroom.
10. It will be difficult for me to read texts in my science classroom.
11. I feel confident that I will be able to learn how to read texts in my science classroom.
12. Reading texts in my science classroom is easy for me.

Science and Reading Task-Value Items (name not to be displayed to students):

(1. Not useful at all; 2.; 3. Average; 4.; 5. Very useful)

1. Compared to other subjects you learn in school, how useful is learning about science?
2. Compared to other subjects you learn in school, how useful is learning about microbiology?
3. Compared to other subjects you learn in school, how useful is learning about how to read texts in my science classroom?
4. Compared to other subjects you learn in school, how important is learning about science?
5. Compared to other subjects you learn in school, how important is learning about microbiology?
6. Compared to other subjects you learn in school, how important is learning about how to read texts in my science classroom?

Motivations for Reading Questionnaire (name not to be displayed to students)

We are interested in beliefs you have about your reading. Please read the following sentences and indicate the answer (very different from me, somewhat different from me, somewhat like me, a lot like me) that is related to you and the way you are when you are doing school work or home work. Please answer as honestly as possible.

<b>Very Different From Me</b>	<b>Somewhat Different From Me</b>	<b>Somewhat Like Me</b>	<b>A Lot Like Me</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>

- \_\_\_\_\_ 1. I know that I will do well in reading next year.
- \_\_\_\_\_ 2. I like hard, challenging books.
- \_\_\_\_\_ 3. I am a good reader.
- \_\_\_\_\_ 4. I learn more from reading than most students in the class.
- \_\_\_\_\_ 5. If the project is interesting, I can read difficult material.
- \_\_\_\_\_ 6. I like it when the questions in books make me think.
- \_\_\_\_\_ 7. I usually learn difficult things by reading.
- \_\_\_\_\_ 8. If a book is interesting I don't care how hard it is to read.
- \_\_\_\_\_ 9. I am confident that I understand what I read.
- \_\_\_\_\_ 10. I can do well when tested on what I read.
- \_\_\_\_\_ 11. When I don't understand something while I'm reading I know a strategy that  
can help me.
- \_\_\_\_\_ 12. After I read something I can usually explain what I read to others.
- \_\_\_\_\_ 13. If my teacher shows me something to help me read better I know I can do it.

\_\_\_\_\_ 14. I'm sure I could understand the main idea of a new story I read.

\_\_\_\_\_ 15. When I'm reading and I get stuck I can find figure out the problem.

Task Situational Interest Questions (Rotgans & Schmidt, 2012)

Questions will be presented following each reading passage.

1. I am fully focused on today's activity.
2. I am currently distracted by other things.
3. I am enjoying this activity.
4. I thought this reading passage was interesting.
5. I enjoyed this passage.

Perceived Interest Questionnaire (adapted from Schraw, et al., 1995)

\* "Crystal Island" will be changed to "today's activity" for the classroom game-based and PowerPoint condition.

1. I thought Crystal Island was very interesting.
2. I'd like to discuss Crystal Island with others at some point.
3. I would play Crystal Island again if I had the chance.
4. I got absorbed playing Crystal Island without trying to.
5. I will probably think about what I learned playing Crystal Island for some time to come.
6. I thought Crystal Island's topic was fascinating.
7. Crystal Island was personally relevant to me.
8. I would like to play more games like Crystal Island in the future.
9. Crystal Island was one of the most interesting games I have played in a long time.

10. Crystal Island really grabbed my attention.

Overall Experience Questions

<b>Uninteresting</b>	<b>Of little interest</b>	<b>Undecided</b>	<b>Somewhat interesting</b>	<b>Very interesting</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

**Game-based learning condition**

To what degree did you find each of the following features of today's activity particularly interesting?

- a. Talking with characters in the game (social interaction)
- b. Testing objects (interactivity)
- c. Filling out the diagnosis worksheet (interactivity)
- d. That you were playing a game (novelty)
- e. The 3D gameworld (interactivity)
- f. The challenge of solving the mystery (meaningfulness, novelty)
- g. Making your own choices (meaningfulness)
- h. Reading and applying the texts

**Classroom game-based learning condition**

To what degree did you find each of the following features of today's activity particularly interesting?

- a. Reading the characters' dialog (social interaction)
- b. Testing objects (interactivity)

- c. Filling out the diagnosis worksheet (interactivity)
- d. That you were completing a hands-on activity (novelty)
- e. The challenge of solving the mystery (meaningfulness)
- f. Making your own choices (meaningfulness)
- g. Reading and applying the texts

### **PowerPoint learning condition**

To what degree did you find each of the following features of today's activity particularly interesting?

- a. Filling out the note-taking worksheet (interactivity)
- b. Doing work on the computer (novelty)
- c. Going at your own pace (meaningfulness)
- d. Reading and applying the texts

Specifically, what would make today's activity more interesting?

### Microbiology Content Test

Item

1. Which of the following statements best describes bacteria and viruses?
  - a. Bacteria and viruses are BOTH considered alive.
  - b. Bacteria are considered alive, but viruses are NOT considered alive.
  - c. Viruses are considered alive, but bacteria are NOT considered alive.
  - d. Viruses are NOT considered alive, and bacteria are NOT considered alive.

FACT

2. You observe a biological agent and notice that it does NOT have a nucleus. What type of agent might you be looking at?
- Bacterium
  - Carcinogen
  - Virus
  - Either a virus or a bacterium

APP

3. Your friend is feeling ill and goes to the doctor. The doctor gives your friend an antibiotic and as a result your friend begins to feel better soon afterwards. What infectious agent likely made your friend sick?
- Bacterium
  - Carcinogen
  - Virus
  - Either a virus or a bacterium

APP

4. Your lab partners are examining a pathogen through a microscope and have observed that it is smooth and round in shape. What pathogen are your lab partners probably looking at?
- Bacterium
  - Carcinogen
  - Virus
  - Either a virus and a bacterium

APP

5. Which of the following statements about viruses is true?
- Viruses are considered the smallest living cells.
  - Viruses consist of genetic material within a capsid.
  - Viruses reproduce through binary fission.
  - Virus specimens can be viewed through an optical microscope.

FACT

6. Which of the following diseases is caused by a viral infection?
- Anthrax
  - Influenza
  - Salmonellosis
  - Sickle cell

FACT

7. What type of pathogen is considered the smallest living microorganism?
- Bacterium
  - Carcinogen
  - Fungi
  - Virus

FACT

8. An illness has been spreading through a town, and doctors have told sick people to remain at home until they are well. The spread of the illness appears to have been stopped due to the doctors' instructions. What does this tell you must be true about the illness?
- It was caused by a mutagen because it spread from one organism to another.
  - It was caused by a pathogen because it spread from one organism to another.
  - It was caused by a carcinogen because it spread from one organism to another.
  - It was not caused by a mutagen, carcinogen, or pathogen.

APP

9. Which of the following statements about pathogens is true?
- Any pathogen can be treated with antibiotics.
  - Pathogens are considered living microorganisms.
  - Pathogens are only responsible for a few hundred deaths each year.
  - Pathogens spread from person to person.

FACT

10. You have determined that your patients' disease has been caused by a genetic mutation. Knowing this you can determine that the disease was caused by
- A bacterium.
  - A virus.
  - A mutagen.
  - None of the above.

APP

11. Which of the following treatments is generally considered the most effective way to reduce the likelihood of a viral infection?
- Antibiotic
  - Chemotherapy
  - Surgery
  - Vaccine

FACT

12. Your friend began to feel sick this morning and is showing the following symptoms: stomach cramps, fever, and severe diarrhea. She suspects that the source of her illness was some suspicious-looking hamburger meat she ate yesterday. Which of the following diseases is she likely suffering from?
- Anthrax
  - Botulism
  - Influenza
  - Salmonellosis

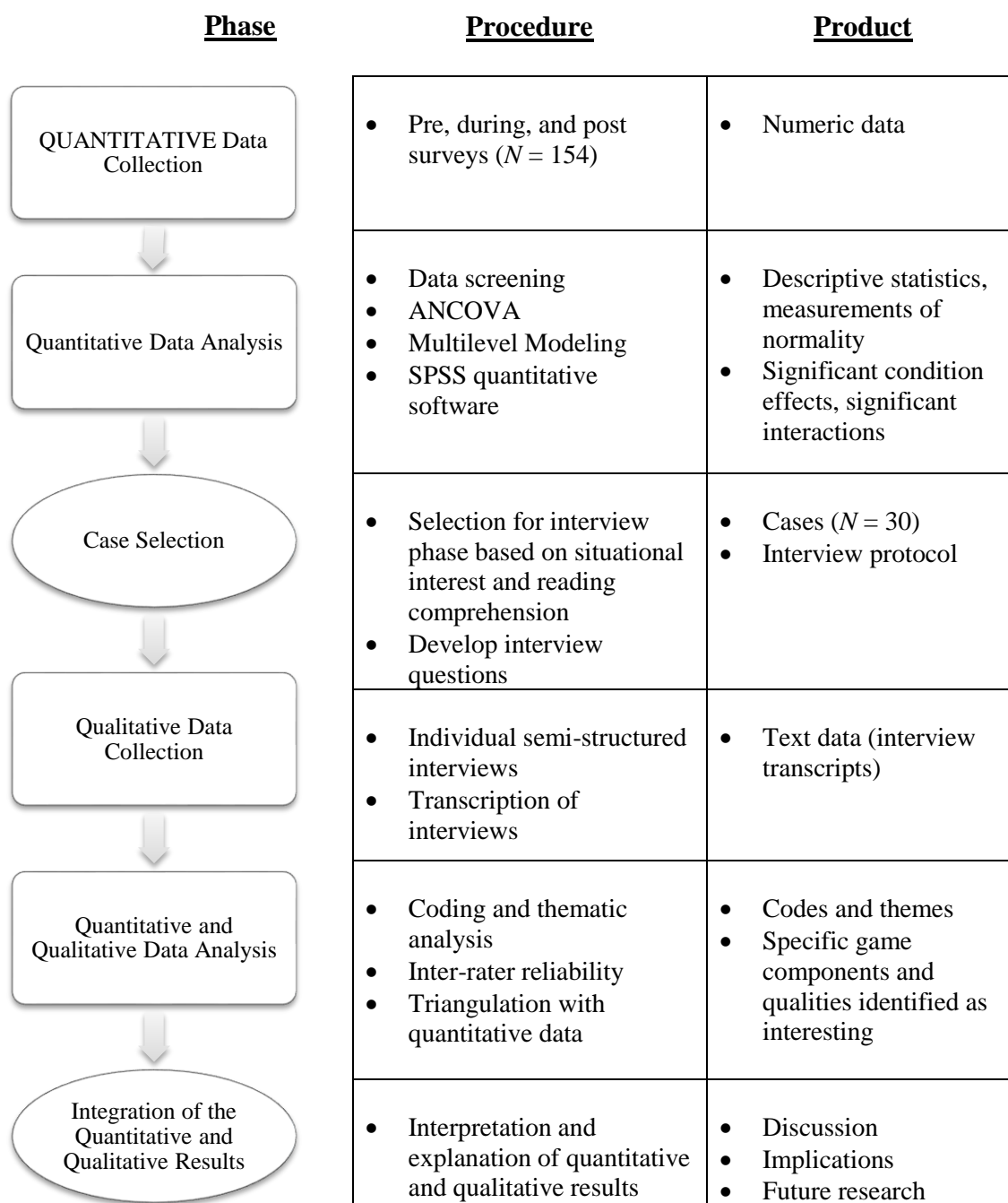
APP

13. Which of the following statements about viruses and bacteria is TRUE?
- All viruses and bacteria are harmful to humans.
  - All viruses and bacteria are considered pathogens.

- c. Both viruses and bacteria are composed of small cells.
  - d. Some viruses and bacteria are not harmful to humans.
- FACT

## Appendix B

## Study Method Diagram



## Appendix C

### Expository Texts

#### **Scientific Method**

When a person bakes cookies, he follows a recipe. When a scientist approaches a problem or wishes to discover new knowledge, she uses a "recipe" for problem solving called the scientific method.

Unlike a recipe, which is linear, the scientific method is cyclical. The scientific method begins with a problem. The problem must first be identified. After gathering background information, a hypothesis--a possible solution for the problem--should be created. The hypothesis can be tested by performing experiments and collecting data about the problem. After collecting observational data, the problem and/or hypothesis may be redefined, which leads to more experimentation.

If the original data was satisfactory, then the data can be analyzed. Analysis involves careful examination of the data in order to detect patterns, differences, or trends observed in the experiment. The conclusions from the analysis are then shared with other scientists and the public. After reporting findings, the problem may be redefined and the process repeats again.

The scientific method is:

- A. A recipe for solving a problem**
- B. A book about microbiology
- C. A type of data
- D. A report of scientific findings

A hypothesis is:

- A. Another name for analyzing data.
- B. The only solution for a problem.
- C. A type of scientist.
- D. A possible solution for a problem.**

Which of the following statements is true?

- A. Once a hypothesis is formed, you cannot change it.
- B. You need a microscope to analyze all types of data.
- C. Anyone can use the scientific method, not just scientists.**
- D. No steps of the scientific method should be repeated.

Lisa recently collected samples of water across her city in order to determine overall water quality. Using the scientific method, what is Lisa doing as she analyzes each sample?

- A. Gathering background information
- B. Analyzing results**
- C. Reporting results
- D. Stating the problem

Lexile: 870

Mean Sentence Length: 12.00

Mean Word Frequency: 3.37

Word Count: 132

### **How do diseases spread?**

No one wants to be sick. You can protect yourself from getting sick by taking the necessary measures to protect yourself. Infectious diseases are illnesses caused by pathogens. Examples of pathogens are parasites, bacteria, viruses, and fungi.

Pathogens can be transmitted in several different ways. Physical contact with contaminated food and water, body fluids, and airborne pathogens are ways that diseases are transmitted. If a disease is easily transmitted, it is considered contagious.

#### How to Prevent the Spread of Disease

Pathogens are transmitted or carried by a vector. A vector could be a person, animal, or microorganism. Since direct contact is a common means of transmission, the best way to prevent the spread of disease is to properly wash your hands. Properly washing and cooking foods are also helpful to prevent the transmission of pathogens. Since respiratory illnesses are spread through inhalation of pathogens, it is helpful to avoid contact with those who are coughing and sneezing. Bodily fluids may also carry pathogens. Therefore, you should avoid contact with bodily fluids. By taking these steps, you will decrease your chances of infection.

Which of the following is a pathogen?

- A. Virus
- B. Fungus
- C. Parasite
- D. A and B only
- E. All of the above**

What is the best way to prevent the spread of disease?

- A. Stay indoors
- B. Wash your hands**
- C. Wear protective footwear
- D. Avoid farm animals

A vector could be:

- A. A friend
- B. A piece of chicken
- C. A flea
- D. A and C only
- E. All of the above**

Yesterday, 4 students at Hillside Middle School reported feeling sick and sneezed frequently throughout the day. Today, 20 students reported similar symptoms. The illness at Hillside Middle must be:

- A. A sign the school should be closed.
- B. Contagious.**

C. Due to a water-borne pathogen.

D. A vector.

Lexile: 980

Mean Sentence Length: 12.81

Mean Word Frequency: 3.21

Word Count: 205

### **Immunization**

What prevents people from getting common infectious diseases like influenza and chicken pox? One way to avoid disease is to get immunized. Being immune means that a person has built up resistance, or antibodies, against a given disease.

The most common way to be immunized is to visit your doctor or health care provider and request a vaccine. A vaccine is typically a shot that contains a weakened or dead form of the infectious disease, or “germ.” The body is tricked into thinking that a germ has infiltrated it, and the body immediately begins making antibodies to fight against it.

Antibodies are proteins in the blood that can detect an outside invader to the body. As soon as the antibody is alerted to outside attack from germs, chemicals are produced that “bind” the invader. The result is a neutralized germ with no power to harm the normal cells of the body. Eventually, the invading germ is destroyed.

Sometimes the body needs several doses of a vaccine over an extended period of time in order to build up enough resistance. The body’s cells develop a memory of the germ so that

if they encounter the germ again, they will immediately begin producing the appropriate antibodies and destroy the germ.

Through widespread vaccination programs, disease can be controlled and eventually eliminated. Smallpox, for instance, was eliminated through worldwide vaccination programs. Other infectious diseases are becoming more rare in the United States, such as polio. It is important to get vaccinations to keep up society's level of immunity. The more people are vaccinated, the less likely society will face severe infectious diseases that make us very ill or even cause death.

Antibodies:

- A. are a type of germ.
- B. are a type of vaccinations.
- C. neutralize germs.**
- D. cause infectious diseases.

A vaccine is:

- A. A person that has built up resistance against a given disease.
- B. A shot that contains a form of an infectious disease.**
- C. A shot that contains antibodies to fight against an infection disease.
- D. A neutralized germ.

Smallpox is no longer a threat to the world mainly because:

- A. We can get vaccinated.
- B. Polio is more common.
- C. The disease has been eradicated.**
- D. None of the above. Smallpox is still a threat.

Jim feels he is coming down with a virus. After a couple of days of feeling ill, he goes to the doctor and asks for a vaccine. The doctor most likely:

- A. Gave Jim a vaccine.
- B. Told Jim vaccines are only effective before getting sick.**
- C. Gave Jim an antibody.
- D. Told Jim he was immune to the virus.

Lexile: 1090

Mean Sentence Length: 15.83

Mean Word Frequency: 3.33

## **Bacteria**

What are bacteria?

Bacteria are microorganisms, which perform many different functions in the world. Some bacteria are used in the production of cheeses and fermented meats. Other bacteria are used to make pharmaceutical products. Recently, bacteria have even been used to reduce pollution.

Are bacteria harmful?

Most bacteria are not harmful. A few, however, cause human diseases such as listeria and shigellosis. Listeria is a type of bacteria found in soil, water, and even some poultry and cattle. Listeria is unusual in that it is able to grow in cold spaces like the refrigerator. The elderly, pregnant women, and the chronically ill are most susceptible to serious illness from listeria.

Shigella cause intestinal infections called shigellosis. Shigella bacteria are spread from person to person. The most common symptom is diarrhea, and the best treatment is to rest and drink plenty of fluids.

Antibiotic treatment

Scientists have also developed a group of drugs that combat bacterial infections called antibiotics. Antibiotics can be prescribed for listeria infections. However, they may not be used in mild cases of shigellosis due to the possibility of the bacteria building a resistance.

Bacteria:

- A. have been used to reduce pollution
- B. are used to create cheese.
- C. are used to create pharmaceuticals.
- D. All of the Above.**

Listeria:

- A. is a type of illness.
- B. is a type of bacteria.**
- C. is an antibiotic.
- D. is a famous scientist.

Strep throat, caused by a form of bacteria called streptococci, is a common bacterial infection. How can you cure strep throat?

- A. Get vaccinated.
- B. Avoid poultry and cattle.
- C. Take an antibiotic.**
- D. There is no cure for a bacterial infection.

Bacteria are needed to make yogurt, but eating yogurt does not necessarily mean you will get a bacterial infection. What can you reasonably conclude from this statement?

- A. Yogurt contains very small amounts of bacteria so that it is not harmful to humans.
- B. Not all bacteria are pathogens.**
- C. People who eat yogurt often should take an antibiotic.
- D. Pregnant woman and the elderly should avoid yogurt.

Lexile: 830

Mean Sentence Length: 10.64

Mean Word Frequency: 3.25

Word Count: 166

## Viruses

What is a virus?

Viruses are nonliving. Viruses depend on hosts to receive nutrients to reproduce.

Viruses do not use nutrients to live, but they can only reproduce once they have nutrients.

This reproduction process resembles an echo in the mountains. For example, one echo causes another echo, which causes another. Even though one echo produces another, an echo is not a living thing.

One virus, called a T4 bacteriophage, can attach itself to E. coli bacteria and inject genetic material. The injected genetic material carries a special code that is used to produce more and more viruses. After many viruses have been produced, the original bacteria cell explodes. The new viruses travel to other bacteria and continue to reproduce in their new bacteria hosts. The viruses cannot reproduce on their own; they depend on their bacteria hosts for reproduction. For this reason, some strains of E. coli bacteria are very deadly.

Transmission of these bacteria usually occurs through contaminated food or water, following contact with animals, and occasionally from person to person.

What are the differences between viruses and bacteria?

There are several differences between viruses and bacteria. The first major difference is size. Viruses are much smaller than bacteria cells. Another difference is that bacteria are alive and reproduce on their own, whereas viruses are not considered alive and they need to have hosts to reproduce.

Most viruses are harmful to their hosts. In contrast, bacteria can often be helpful. For example, some bacteria help the environment through the decomposition of waste products.

Recently, scientists have discovered a way to change the genetic make-up of some viruses. The changed virus is used as a type of drug to fight diseases such as cancer. While viruses cause many diseases, perhaps future research can make viruses useful in fighting illness.

Viruses are like an echo because?

- A. You cannot see an echo.
- B. Echoes travel in the shape of a wave.
- C. Echoes reproduce but are non-living.**
- D. Echoes can be harmful if they are too loud.

E. Coli:

- A. Is always deadly.
- B. Can act as a host to a virus.
- C. Is a bacteria.
- D. Both B and C.**

Hepatitis B is a virus that attaches itself to liver cells. In this case, liver cells:

- A. **Are a host.**
- B. Are E. coli.
- C. Provide nutrients for the virus to reproduce.
- D. A and C only.
- E. All of the above.

A local scientist recently released a new drug. The drug contains a certain virus for curing a common disease. The scientist most likely made the drug by:

- A. Attaching the virus to bacteria.
- B. **Changing the genetic material of the virus.**
- C. This cannot be true. All viruses are harmful to humans.
- D. None of the Above.

Lexile Score: 910

Mean sentence Length: 12.08

Mean Word Frequency: 3.28

Word Count: 314

## **Salmonellosis**

### Definition of Salmonellosis

Salmonella is a rod shaped bacteria in the bacillus genus. Salmonellosis is an illness caused by the bacilli Salmonella. These bacteria are passed to animals and people through feces.

The Surveillance Report from the Food Diseases Active Surveillance states that Salmonellosis is the most commonly reported bacterial infection. Two types of Salmonella bacteria are the cause of about half of human infections. The infection does not exhibit symptoms in all people. Most infected patients experience fever, abdominal cramps, and diarrhea within a few hours to a few days of infection.

Most people get better in a few days without seeing a doctor. People with chronic medical conditions, the elderly, young children, and pregnant women are at a higher risk for developing serious complications, and they should seek medical attention if Salmonellosis is suspected.

### Prevention of Salmonellosis

Salmonella lives in the intestinal tract of animals and humans. It is usually transmitted to humans by eating food that has been accidentally contaminated with fecal matter.

According to the United States Department of Agriculture (USDA), several steps can be taken to prevent the contamination of food. It is essential that people wash their hands after coming into contact with feces. Common situations where contact with feces can occur include handling pets, changing diapers, or going to the bathroom.

Food preparation areas and materials should be cleaned thoroughly throughout cooking. While preparing food, raw meats should be separated from other foods and separate utensils should be used. Food should be cooked to the proper internal temperature. Also, food should be refrigerated properly. Following these steps will help to reduce the possibility of contracting and spreading Salmonellosis.

Which of the following is true about Salmonellosis:

- A. Salmonellosis is often transmitted by sneezing or coughing.
- B. Salmonellosis cannot be avoided.
- C. No one that gets Salmonellosis needs to see a doctor.
- D. Salmonellosis lives in the intestinal tract of animals and humans.**

Salmonellosis is:

- A. A virus.
- B. The most commonly reported bacterial infection.**
- C. extremely deadly.
- D. The “S” is USDA.

David is afraid he might have contracted Salmonellosis. What piece of evidence best confirms this hypothesis?

- A. He is experiencing fever, abdominal cramps, and diarrhea.**
- B. He is an elderly man.
- C. He drank a glass of milk.
- D. He played fetch with his dog earlier.

You have been selected to inspect a local restaurant to make sure they are being safe and responsible. Which of the following would you check to make sure Salmonellosis is not a threat to the restaurant?

- A. Where raw meat is stored.
- B. If the restaurant has thermometers for testing the internal temperature of meats.
- C. Where the cooks cut raw meat.
- D. All of the above.**

Lexile Score: 1000

Mean Sentence Length: 13.30

Mean Word Frequency: 3.23

Word Count: 266

## **Influenza**

What is Influenza?

Influenza, better known as the flu, is a contagious infection that affects the respiratory system. The severity of the flu ranges from mild to severe, and it can even lead to death. The flu has several different types, including types A, B, and C. The types are categorized by protein composition in the flu virus structure.

The flu virus is round shaped with a layer of spikes on the surface. The spikes help copied viruses get out of the host or stick to the cell. Flu may infect birds, animals, and humans.

## Symptoms of Influenza

According to the National Institute of Allergy and Infectious Diseases, some or all the symptoms of the flu may be seen in an infected person. The symptoms are fever, cough, sore throat, aches, fatigue, and runny or stuffy nose.

The flu spreads through direct contact with the virus. The virus can live in the tiny drops from coughing, sneezing, or talking. The drops may land on a person or be picked-up by a person who then touches their mouth, eyes or nose.

A key line of defense against spreading flu is proper hand washing, especially during flu season. Infected people are contagious before developing symptoms, and they remain contagious for several days after symptoms occur. Since the symptoms are similar to many other infections, a doctor's exam can help determine if a person is infected with the flu. The diagnosis can be confirmed with a test.

The elderly, young children, pregnant women and chronically ill have a greater risk of developing complications from the flu. Complications include pneumonia, ear infections, sinus infections, and/or worsening chronic medical conditions.

## Prevention of Influenza

The flu vaccine is the best way to prevent the flu. The Centers for Disease Control (CDC) recommend that everyone 6 months and older get the flu vaccine each year. The vaccine should be taken in the fall of each year. There are two ways to get the vaccination. The shot vaccine uses an inactive or killed virus, and it is injected with a needle. The nasal

spray vaccine has a live, weakened virus, which is sprayed into the nose. The body produces antibodies to protect against the flu over the course of two weeks after vaccination.

The flu vaccine changes each year. The seasonal vaccine has three flu viruses, which researchers predict will be the most common during the upcoming flu season.

Which of the following statements is true?

- A. All influenza viruses are the same.
- B. Everyone with the flu shows all of these symptoms: fever, cough, sore throat, aches, fatigue, and runny and stuffy nose.
- C. There is no test for the influenza virus.
- D. The flu vaccine is the best way to prevent the flu.**

Influenza is most commonly transmitted by:

- A. Cattle and other livestock.
- B. Tiny drops from coughing, sneezing, or talking.**
- C. Raw meats.
- D. Washing your hands.

Kristin had a flu shot last year, so she does not feel like she needs one this year. Why would you recommend she get vaccinated again this year?

- A. The flu virus is round shaped with a layer of spikes on the surface, which help copied viruses get out of the host or stick to the cell.
- B. You would not recommend it because Kristin washes her hands a lot.
- C. Kristin got the flu shot last year instead of the nasal spray.
- D. There are many types of flu viruses and the threat is constantly changing.**

Juan's mom thinks he has influenza, but, Juan explained this couldn't be true because he has not been around anyone showing symptoms of influenza. Do you think Juan is correct?

- A. Yes, people cannot transmit influenza unless they are showing symptoms.
- B. No, people can transmit influenza before they show symptoms.**
- C. No, influenza is most often transmitted through food.
- D. None of the above.

Lexile: 1110

Mean Sentence Length: 15.04

Mean Word Frequency: 3.18

Word Count: 406

## Appendix D

### Interview Protocol

#### Student Interview Protocol (Case Studies)

*This semi-structured interview contains the questions that were asked of students after interacting with the condition activity. All questions were asked at least one time. The order of these questions did vary slightly from interview to interview.*

Thank you for agreeing to participate in this interview for our Crystal Island project! We have a series of questions to ask you. Please answer honestly and openly. There are not right or wrong answers. Also, you may decline to answer any question that makes you uncomfortable. Are you ready to get started?

1. Do you enjoy reading?
2. How often do you read?
3. How important is reading to you?
4. How would you assess your reading abilities?
5. Describe your experience with the activity.
6. Would you like to do the activity again? Why?
7. What was your favorite part of the activity?
8. What features of today's activity did you find interesting?
  - a. Examples: talking with characters, playing a game, being on the computer, solving the mystery

## Appendix E

### Description of Conditions

#### **Game-based Learning**

Students in the game-based learning condition first watched the CRYSTAL ISLAND: LOST INVESTIGATION backstory video. Then, students entered the game world and complete the tutorial level of the game acquainting students to the controls. From here, students played through the game. Voice over dialog was removed for consistency across conditions.

The game was intentionally autonomous, therefore, students were free to read texts, talk to characters, and engage in game-based activities in any order they please. However, the texts were placed around the environment such that students following the most common game path will come across texts in order they are presented in the other conditions. At the end of each text, students were prompted to make a rating of their current situational interest via paper-pencil.

### **Classroom game-based Learning**

Students in the classroom game-based learning condition received an activity packet containing:

- Diagnosis worksheet
- 7 Expository texts
- Introduction to the overall task
- 4 activity pages

Students completed the packet in the following order:

1. Introduction
2. Read: Scientific Method
3. Interview Characters
4. Read: How Do Diseases Spread?,
5. Gather Information
6. Read: Viruses, Bacteria
7. Test Objects
8. Read: Salmonellas, Influenza, Immunization
9. Submit Diagnosis

Name: \_\_\_\_\_

**Diagnosis Worksheet**

**1) Patients' Symptoms**

Symptom A	Symptom B
Symptom C	Symptom D

**2) Test Results**

<i>Object Name:</i> _____	<i>Result:</i> _____
---------------------------	----------------------

**3) Possible Explanations**

<i>Likelihood:</i>	<i>Because:</i>
Anthrax	
Botulism	
Ebola	
Influenza	
Salmonellosis	
Smallpox	

**4) Diagnosis**

Disease \_\_\_\_\_

Source \_\_\_\_\_


Treatment \_\_\_\_\_

Figure E.1. Diagnosis Worksheet.

*Introduction from Kim, the camp nurse.*

Students received the same introduction presented within the game by Kim Lee, the camp nurse. Kim informed the player of the overall problem.

**Welcome to Crystal Island**  
**WE NEED YOUR HELP!**



"Thank goodness you're here! I'm Kim, the camp nurse. People on the island are getting sick, and we don't know why. Please, can you help us?"

"You can gather clues by talking to other team members and testing objects. To solve the mystery, you must complete the diagnosis worksheet.

"The illness spread through the camp a couple days ago. So far, all we know is that it's either a pathogen, a mutagen, or a carcinogen."

"Pathogens are biological organisms that cause disease or illness to their host. The main characteristics of pathogens are that they make people ill, they require hosts, and can spread from one host to another."

"Mutagens are agents that can change the genetic information, like DNA, of organisms. Some mutagens cause cancer, making them carcinogens as well. Mutagens cannot spread from person to person like pathogens."

"Carcinogens are agents that promote or facilitate cancer. Cancers are diseases that affect the cells of patients' bodies. Carcinogens cannot spread from one person to the next like pathogens."

Figure E.2. Kim's Introduction.

*Activity 1: Character interviews*

In this activity, students had the opportunity to read about the symptoms of the sick characters of Crystal Island. The pictures below were provided to the students as well as the exact dialog presented within the game. Students were able to take notes and fill in their diagnosis worksheet accordingly.


<b>Character Interviews</b>	
On this page you will find accounts of the sick patients of Crystal Island.	
<b>Bryce Reid: Lead Scientist</b>	
	“I'm sorry, but I don't feel up to chatting. This sore throat and fever are terrible. I think I caught something in the dining hall.”
<b>Teresa Moore: Research Scientist</b>	
	“I've had a cough, fever, and sore throat for days, and sometimes it hurts to breathe.” “I felt fine until a couple of days ago. Everyone I usually eat breakfast with is sick now too.”
<b>Samuel Hasimoto: Research Scientist</b>	
	“Uuuuuuh, my throat hurts.”
<b>Gergory Martin: Research Scientist</b>	
	“I think I have a fever. Do I feel warm? I'm so tired.”

Figure E.3. Character Interviews.

### Activity 2: Gather information

During this activity, students gathered additional information. To do so, students were given the dialog presented by the virus and bacteria expert in the game environments. Also, students had access to the informational posters displayed around the island.




<b>Gathering Information</b>		<b>Gathering Information</b>	
On this page you will find expert accounts of microbiology topics.		On this page you will find account of Quentin, the camp cook.	
<p><b>Robert Campbell: Bacteria Expert</b></p>  <p>"I am the camp's foremost expert on bacteriology. If you need to know anything about bacteria, I'm sure I can help."</p> <p>"Bacteria can be pathogens. They need a host, can spread from person to person, and cause illness. Many are harmless to humans."</p> <p>"Bacteria are the smallest type of living organism, as small as 200 nanometers. They're bigger than viruses, but still very small."</p> <p>"Not all bacteria are pathogens. In fact, there are twenty-five different types of bacteria in your mouth alone. And you look healthy!"</p> <p>"Bacteria can be spiral-shaped, rod-shaped, or round."</p> <p>"Bacteria are single-celled organisms without nuclei. Structurally, they have a cell wall and genetic material."</p>	<p><b>Ford Patterson: Virus Expert</b></p>  <p>"I am the team's virus expert. I've only been on the island for a few weeks, but I don't know how these people ever did anything without me!"</p> <p>"Viruses are a type of pathogen. They need a host for survival, can cause illness, and spread between people."</p> <p>"Viruses are the smallest type of pathogen. They are smaller than 200 nanometers in size, which means they are extremely tiny."</p> <p>"Viruses come in lots of strange shapes, like skinny sticks, looped strings, polyhedrals, spiky orbs, bricks, bricks with round corners, and lunar landing pods."</p> <p>"Virus structures have a capsid and genetic material. They are NOT cells, so they have a very different structure than cells."</p> <p>"Viruses are NOT alive. They can't reproduce on their own, they can't respond to their environment, and they don't grow. Also, not all viruses are harmful to humans. For example, feline immunodeficiency virus is one that affects cats, but not humans."</p>	 <p>"My name's Quentin Nash. Kim told me that you're gathering clues about this mysterious illness going around."</p> <p>"I am the camp's main cook. People have mostly been eating eggs, toast, bananas, and oranges. And we have water and milk to drink, too."</p> <p>"Also, I was sick several days ago, although I'm feeling better now. I had a terrible cough, sore throat, and a fever. It even hurt to breath. I got a lot of rest, and eventually started to feel better."</p> <p>"I drank some milk, then felt pretty sick afterward. I think there was something wrong with it. Maybe you could run a test in the lab to see if it's contaminated?"</p>	

Figure E.4. Gathering Information.











*Activity 3: Testing*

In this activity, students were able to choose objects from a list that they wish to test for contaminants. Students filled out a card outlining their rationale for testing the object and presented the card to either the facilitator or their instructor. The instructor or facilitator informed the student whether the object is contaminated or not.

### Testing Objects

On this page, you will choose objects to test to see if they are contaminated.

**1) Choose an object to test:**

**2) State your hypothesis:**

I think it is contaminated with:	Why are you testing this object?
Select one: Virus, Bacteria, Carcinogen, Fungus	Select one: Sick people ate/drank it, Sick members touched it, It looked dirty, It often carries diseases

Figure E.5. Testing Objects.

#### *Activity 4: Submit diagnosis*

Similar to the testing activity, students completed the diagnosis section of the diagnosis worksheet and submitted the worksheet to either the facilitator or the instructor. Students received feedback regarding the correctness of the worksheet. Students with incorrect submissions were asked to try again.

#### **PowerPoint**

Students in the PowerPoint condition interacted with a PowerPoint presentation designed to cover all of the microbiology content found within the other conditions. Students were provided with a structured note-taking matrix to use during the activity. Also, embedded within the PowerPoint were the expository texts presented on screen in plain text form.

Specifically, the PowerPoint presentation consisted of approximately 40 slides and covered the following sections (presentation of texts are in bold):

- The scientific method
- **Scientific Method text**
- Introduction to pathogens
- **How do Diseases Spread? text**
- Viruses
- Bacteria
- Analyzing pathogens with a microscope
  - Size and shape differences between pathogens
- **Virus text, Bacteria text**
- Reproduction of pathogens
- Types of diseases
  - Introduction
  - Explanation of symptoms
  - Treatment options
- **Salmonellas text, Influenza text, Immunization text**

**Name:** \_\_\_\_\_

**Note-Taking Worksheet**

<b>Viruses</b>	<b>Bacteria</b>
Description	
Defining features (example: size, shape)	
How do they reproduce?	
How do they spread?	
Associated diseases	

Figure E.6. Matrix Note-Taking Worksheet.

## Appendix F

### Additional Multilevel Modeling Analysis

An intercepts and slopes as outcomes model controlling for prior knowledge was conducted to answer the following questions: 1) Do differences in levels of situational interest between conditions depend on prior knowledge?, 2) Does change in situational interest depend on prior knowledge?, 3) Do students vary in that change?, and 4) Is there a cross-level interaction? The following equations were entered into the analysis:

$$\begin{aligned} \text{Level 1: } DV_{ij} &= \beta_{0it} + \beta_{1it}(\text{TIME}) + r_{it} \\ \text{Level 2: } \beta_{0i} &= \gamma_{00} + \gamma_{01}(\text{Condition}) + \gamma_{02}(\text{Prior Knowledge}) + u_{0i} \\ \beta_{1i} &= \gamma_{10} + \gamma_{11}(\text{Condition}) + \gamma_{12}(\text{Prior Knowledge}) + u_{1i} \end{aligned}$$

On average, students' levels of situational interest did not fluctuate over the course of the interaction nor was interest dependent upon prior knowledge. However, when controlling for prior knowledge, students in the game-based learning ( $\gamma_{01} = 3.26, t = 5.95, p < .0001$ ) and classroom game-based learning ( $\gamma_{01} = 2.73, t = 4.99, p < .0001$ ) conditions reported significantly higher ratings for situational interest than students in the PowerPoint condition. Furthermore, although game-based learning students' situational interest did not change over time, classroom game-based learning students' situational interest significantly decreased over the course of the interaction as compared to the PowerPoint students ( $\gamma_{11} = -0.29, t = -3.51, p < .001$ ).

To compare levels of situational interest when controlling for prior knowledge between the game-based and classroom game-based learning conditions, new dummy codes were created making the classroom game-based learning condition the intercept. Although no differences in situational interest between the two groups were found, a marginal interaction effect was found with time ( $\gamma_{11} = 0.14, t = 1.75, p < .09$ ) indicating the game-based learning condition was better at sustaining situational interest over time compared to the classroom game-based learning condition. Overall, the model accounted for 16% of the between-student variance and 32% of the within-student variance.

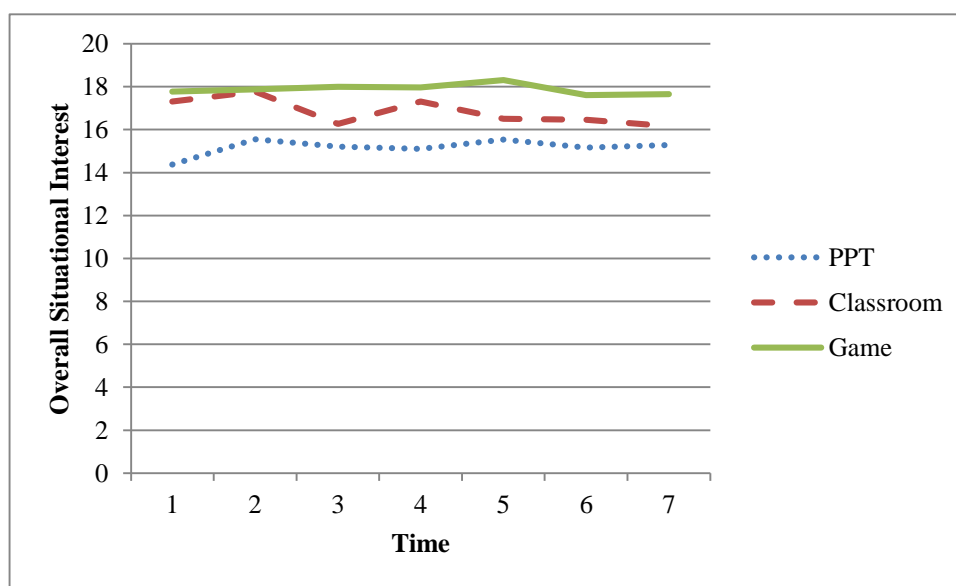


Figure F.1. Student situational interest over time controlling for prior knowledge.

Table F.1

*Unstandardized Coefficients (and Standard Errors) of Multilevel Models of Situational Interest*

Fixed Effects	Model 1	Model 2
<b>Situational Interest, <math>\beta_0</math></b>		
Intercept, $\gamma_{00}$	14.04***(0.58)	16.76***(0.60)
Game-Based, $\gamma_{01}$	3.33***(0.54)	0.53(0.53)
Classroom-Based, $\gamma_{02}$	2.72***(0.55)	
PowerPoint, $\gamma_{03}$		-2.73**(0.54)
<b>Prior Knowledge</b>		
Intercept, $\gamma_{04}$	0.15(0.09)	0.15(0.52)
<b>Time slope, <math>\beta_1</math></b>		
Intercept, $\gamma_{10}$	-0.02(0.08)	-0.32(0.09)
*Game-Based, $\gamma_{11}$	-0.15(0.08)	0.14(0.08)
*Classroom-Based, $\gamma_{12}$	-0.29**(0.08)	
*PowerPoint, $\gamma_{13}$		0.29**(0.08)
*Prior Knowledge, $\gamma_{14}$	0.03(0.01)	0.03(0.02)
<b>Random Effects</b>		
Situational Interest ( $\tau_{00}$ )	8.74***(1.07)	8.74***(1.07)
Interaction ( $\tau_{10}$ )	0.11(0.12)	0.11(0.12)
Time slope ( $\tau_{11}$ )	0.10***(0.03)	0.10***(0.03)
Within-person fluctuation ( $\sigma^2$ )	3.88***(0.17)	3.88***(0.17)

Note: \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

A similar intercepts and slopes as outcomes model was conducted to determine: 1)

Do differences in levels of situational interest between conditions depend on personal interest

in science?, 2) Does change in situational interest depend on prior knowledge?, 3) Do students vary in that change?, and 4) Is there a cross-level interaction?

$$\begin{aligned} \text{Level 1: } DV_{ij} &= \beta_{0it} + \beta_{1it}(\text{TIME}) + r_{it} \\ \text{Level 2: } \beta_{0i} &= \gamma_{00} + \gamma_{01}(\text{Condition}) + \gamma_{02}(\text{Science Interest}) + u_{0i} \\ \beta_{1i} &= \gamma_{10} + \gamma_{11}(\text{Condition}) + \gamma_{12}(\text{Science Interest}) + u_{1i} \end{aligned}$$

Again, no effect of time was found; however, students with high level of interest in science were found to report significantly higher levels of situational interest than students with low science interest ( $\gamma_{02} = 0.12, t = 5.55, p < .0001$ ). Also, when controlling for science interest, students in the game-based ( $\gamma_{01} = 3.32, t = 6.23, p < .0001$ ) and classroom game-based learning ( $\gamma_{01} = 2.72, t = 5.06, p < .0001$ ) conditions reported significantly higher levels of situational interest than students in the PowerPoint condition. As in previous analyses, when controlling for science interest, students' situational interest in the classroom game-based learning condition decreased significantly over time as compared to students' change in interest in the PowerPoint condition ( $\gamma_{11} = -0.29, t = -3.47, p < .001$ ).

To compare levels of situational interest when controlling for prior knowledge between the game-based and classroom game-based learning conditions, new dummy codes were created making the classroom game-based learning condition the intercept. Although no differences in situational interest between the two groups were found, an interaction effect was found with time ( $\gamma_{11} = 0.15, t = 1.89, p = .05$ ) indicating the game-based learning condition was better at sustaining situational interest over time compared to the classroom

game-based learning condition when controlling for the effect of prior interest in science.

Overall, the model accounted for 21% of the between-student variance and 69% of the within-student variance.

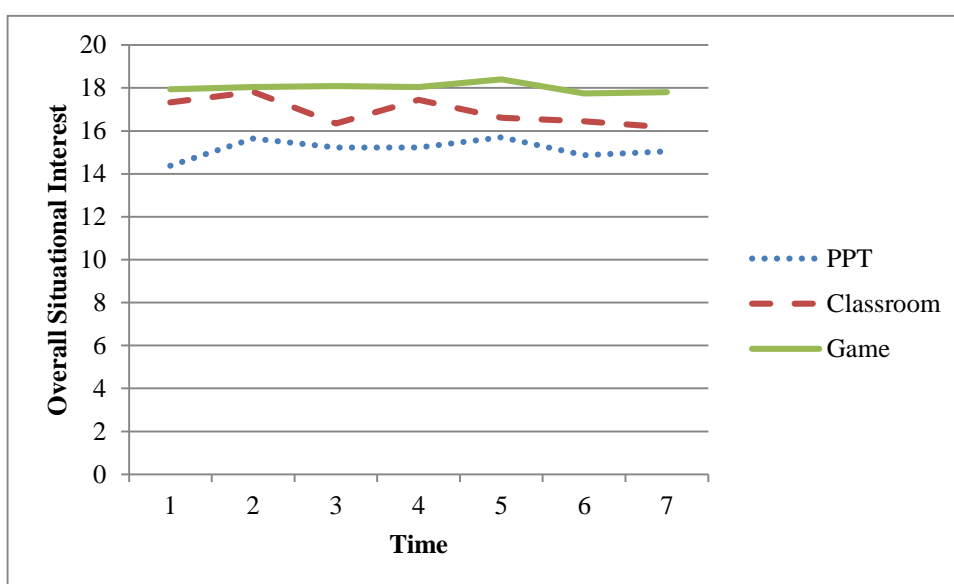


Figure F.2. Students' overall situational interest over time controlling for science interest.

Table F.2

*Unstandardized Coefficients (and Standard Errors) of Multilevel Models of Diagnosis Worksheet Performance*

Fixed Effects	Model 1	Model 2
<b>Situational Interest, <math>\beta_0</math></b>		
Intercept, $\gamma_{00}$	9.57***(1.03)	12.29**(1.00)
Game-Based, $\gamma_{01}$	3.32***(0.53)	0.059(0.50)
Classroom-Based, $\gamma_{02}$	2.72***(0.54)	
PowerPoint, $\gamma_{03}$		-2.72**(0.53)
<b>Science Interest</b>		
Intercept, $\gamma_{04}$	0.12***(0.02)	0.12***(0.02)
<b>Time slope, <math>\beta_1</math></b>		
Intercept, $\gamma_{10}$	-0.18(0.16)	-0.47(0.16)
*Game-Based, $\gamma_{11}$	-0.14(0.08)	0.14*(0.08)
*Classroom-Based, $\gamma_{12}$	-0.29**(0.08)	
*PowerPoint, $\gamma_{13}$		0.29**(0.08)
*Science Interest, $\gamma_{14}$	0.007(0.003)	0.007(0.003)
<b>Random Effects</b>		
Situational Interest ( $\tau_{00}$ )	7.63***(0.98)	7.63***(0.98)
Interaction ( $\tau_{10}$ )	0.03(0.11)	0.02(0.11)
Time slope ( $\tau_{11}$ )	0.10***(0.02)	0.09***(0.02)
Within-person fluctuation ( $\sigma^2$ )	3.66***(0.16)	3.66***(0.16)

Note: \*  $p < .05$ , \*\*  $p < .01$ ,  
 \*\*\*  $p < .001$

## Appendix G

### Interview Coding Manual

**Transcript #:**

Enter file name (number, letter format, e.g., “2a”)

**Condition:**

Choose one: game-based learning/Stackhouse, classroom game-based learning/Phillips,  
PPT/Hoang

***Reading Responses*****Reading Interest:**

Enter corresponding rating using the scale below.

0: No response

1: Not at all interested/enjoys.

2: Neutral. Reads for school, but not for pleasure

3: Very interested/much enjoys. Reads for both school and pleasure

**Reading Ability:**

Enter corresponding rating using the scale below.

0: No response

1: Below grade level/Struggles

2: At grade level/Average

3: Beyond grade level/Exceeds

**Reading Preference:**

Enter the type of reading the student prefers (e.g., Fiction, non-fiction)

**Reading Importance:**

Enter corresponding rating using the scale below.

0: No response

1: Not important

2: Undecided/Slightly important

3: Very important

Circle rationale for importance from the list (may choose more than 1):

Career/college: reading is important to do well in the future, college, or career

Smart/intelligent: reading is important in order to be smart or intelligent

Learn: reading is important because it helps you learn

Other: reading is important because of a reason not listed. Please document the reason.

***Activity Responses*****Specific Sources of Interest (# of mentions, score)**

In the first blank, tally the number of times the student mentions each of the sources below.

In the second blank, enter corresponding rating using the scale below.

-1: Would have added to the student's interest

0: Not mention/response

1: Source was present and added to the student's interest

*Narrative*

Student references the narrative or mystery underlying the activity. For example, references to solving the mystery, playing the role of a researcher/investigator.

*Novelty*

Student comments about how the activity was interesting because it was different than what they normally do in class or school.

*Fantasy*

Student references attributes such as being transported to a fictitious place, pretending, or playing a role.

*Information completeness*

Student suggests the activity was fun because they knew what was going on and had all the information necessary to complete the task.

*Challenge*

Student says he/she liked the challenge of the activity.

*Character Interaction*

Student mentions enjoying reading dialog/talking to/interacting with characters.

*Interactivity/Hands-on*

Student enjoyed doing the hands-on activity. This can include specific components of the game that allowed for manipulation (e.g., running tests).

*Personal Relatedness/Relevancy*

Student liked the fact that the activity mimicked real-world problems/activities. Student was able to see the utility of the activity.

*Autonomy*

Student enjoyed “going at his/her own pace,” and/or doing work on his/her own.

*Technology*

Student mentions being on the computers.

**Notable Quote?**

Answer yes if there is a notable quote from the student that you feel would benefit the write-up. Answer no otherwise.