STARS

University of Central Florida
STARS

2008

Learning African-american History In A Synthetic Learning Environment

Adams Greenwood-Ericksen
University of Central Florida

Part of the Psychology Commons

Find similar works at: https://stars.library.ucf.edu/etd

University of Central Florida Libraries http://library.ucf.edu

University of Central Florida

STARS
Showcase of Text, Archives, Research & Scholarship

LEARNING AFRICAN-AMERICAN HISTORY IN A SYNTHETIC LEARNING
ENVIRONMENT

by

ADAMS GREENWOOD-ERICKSEN
B.S. Washington and Lee University, 2001
M.S. University of Central Florida, 2004

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Psychology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Spring Term
2008

Major Professor: Peter A. Hancock

ABSTRACT

Synthetic Learning Environments (SLEs) represent a hybrid of simulations and games, and in addition to their pedagogical content, rely on elements of story and interactivity to drive engagement with the learning material. The present work examined the differential impact of varying levels of story and interactivity on learning. The 2x2 between subjects design tested learning and retention among 4 different groups of participants, each receiving one of the 4 possible combinations of low and high levels of story and interactivity. Objective assessments of participant performance yielded the unexpected finding that learners using the SLE performed more poorly than any other learning group, including the gold-standard baseline. This result is made even more surprising by the finding that participants rated their enjoyment of and performance in that condition highest among the four conditions in the experiment. This apparent example of metacognitive bias has important implications for understanding how affect, narrative structure, and interactivity impact learning tasks, particularly in synthetic learning environments.

For my family: my mother, who kept pushing me, my father and my sister, who tried to be interested, my grandmother and my brother, who kept it all in perspective, and my wife, who somehow managed to keep from asking when I was going to be done, already. My love to all of you, I couldn't have finished without you.

ACKNOWLEDGMENTS

I would like to acknowledge the invaluable assistance of all of my committee members: Dr. Peter Hancock, Dr. Stephen Fiore, Dr. T. Rudy McDaniel, and Dr. Mustapha Mouloua, as well as my unofficial reviewer, Dr. Pam Greewood. Each is a true master of their discipline, and each of them made important and indispensable contributions to this work. As my Committee Chair, Dr. Hancock's guidance and offhand knowledge of obscure theoretical points and arcane references saved me many hours of wasted time. Dr. Stephen Fiore was the empirical and theoretical architect of this project, and his ideas on the principles of SLE-based learning serve as the underpinnings for this work. Equally, Dr. Rudy McDaniel's ideas on narrative, and its role in creating good learning games were influential to the direction of this work. He deserves further credit for expediting data collection and analysis and for his daily involvement in overseeing my work on those aspects of the project. Dr. Mouloua made invaluable contributions to the structure and organization of this document, and provided truly invaluable assistance in helping me to organize the jumbled mass of ideas that was my dissertation proposal. Finally, Dr. Pam Greenwood, the unofficial fifth member of my committee, probably read more drafts (and draft fragments) than any other committee member. Her influence can be seen in every aspect of this work.

I would also like to thank Dr. Clint Bowers and Dr. Jan Cannon-Bowers, whom an unfortunate (and thankfully, safely concluded) illness prevented from serving on my committee. Nevertheless, their advice, assistance, and financial and logistical support enabled and encouraged me to give serious consideration to this topic as a serious area for study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

LTM   Long Term Memory

NSF   National Science Foundation

SBT   Scenario Based Training

SLE   Synthetic Learning Environment

STM   Short Term Memory, AKA Working Memory

NWN   Neverwinter Nights, a COTS computer game by Bioware

COTS   Commercial, Off The Shelf

FSSS   Florida Sunshine State Standards (a collection of guidelines and requirements intended to standardize the teaching curricula of public school teachers in Florida)

FDOE   Florida Department of Education

CHAPTER ONE: INTRODUCTION

As the arts, sciences, and humanities continue to advance the state of human knowledge, the amount of information that must be learned by students in schools has increased in proportion. At one time, the ability to read, write, and do simple calculations constituted a reasonably complete education. In the modern era, it is common for individuals to find it necessary to earn advanced degrees before entering the workforce in their chosen profession. A modern education may take as long as thirty years, more than a third of even an optimistic estimate of the average lifespan. This increase in knowledge, however, has not been paralleled by improvement in the methods by which material is taught to students. "Tell-test" educational paradigms, which emphasize lecture and traditional testing methods, still represent the most common method of teaching in most schools (Gallagher, 1994). Such passive learning methods are less effective than relatively new technologies made possible by the ubiquity of computers in modern society and a number of aspects of the video game industry (Novak & Gowin, 1984). One new fusion of technology and learning science promises to represent an improved method for engaging learners in an active and interactive teaching environment (Cannon-Bowers, J. A., Fiore, S., Jeanpierre, B., 2003; Fiore, S., 2004; Vogel et al., 2006). Synthetic Learning Environments, or SLE's, represent a combination of two factors known to improve learning performance: contextual anchoring and interactivity.

Synthetic Learning Environments

The SLE is a computer-based system which possesses many of the aspects of a game and/or a simulation. Incorporating sound pedagogical and instructional design principles drawn

from the simulation and gaming domains, the purpose of a SLE is to assist the user in learning information and skills. Such learning environments provide a well-managed *synthetic experience* as a means to enhance learning and performance. Synthetic experience is a well-documented tool for generating experiential learning and enabling learners to practice skills actively. Studies in both the educational (Cannon-Bowers, J. A., Fiore, S., Jeanpierre, B., 2003; CTGV, 1997; Vye et al., 1998)) and training domains (Cannon-Bowers, J. A., Burns, Salas, & Pruitt, 1998) have shown the utility of using synthetic tools to help students develop and practice skills in a controlled and directed environment. It is important to note at this time, however, that the two primary theoretical underpinnings for SLE learning—anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990) and interactive learning (Novak & Gowin, 1984) are well-established. These principles, and others critical to understanding the basis of SLE-based learning, are discussed at greater length later. For the moment, it is enough to say that SLEs contain two main elements that represent these two fundamental and critical theoretical concepts: story and interactivity. The purpose of this work is to examine the effects of each of these, singly and together, on learning using an experimental SLE.

Given the popularity of synthetic environments among a broad section of the learning population (including both schoolchildren and adults), the use of such technologies is an obvious and natural way to impart knowledge. To date, this has been attempted through the use of games developed on the "Edutainment" model. This has met with only limited success. CAI methods, particularly those emphasizing the use of synthetic environments, hold great promise as educational tools- they can provide a compelling, adaptive, and responsive first-hand interactive learning experience. However, that promise has not been kept, perhaps because well-understood principles of learning have not been applied to the design of such systems.

Games as Learning Tools

By incorporating game and story elements into a pedagogically-sound learning environment, SLEs represent a powerful new tool for learning. However, it is critical to consider the practical use of any such system. It cannot be stressed enough that games, like any form of media, are not in themselves capable of creating a learning experience. SLEs, like other forms of serious games, should be thought of as tools designed for specific purposes. Some games are designed purely for entertainment value, some games are designed to investigate alternative choices, and some games are designed, to a greater or a lesser degree, as educational aids. Such games cannot, in and of themselves, be expected to induce learning; however, if properly designed, they might be useful tools to assist learners. Unfortunately there currently exist no explicit principles by which to design such systems. However, decades of research into learning, memory, pedagogy, simulation, and training (collectively referred to as the science of learning) have yielded volumes of knowledge which might be synthesized and applied to the development of such principles. Although the creation or identification of theoretical principles is beyond the scope of the present work, a demonstration of the utility of game technologies as learning tools might help to promote their development. Accordingly, this work examines the effectiveness of one game-related technology as a learning aid in the hope that it will encourage further development of these crucial but misused tools.

The Power of Story

Game format provides significant advantages for learners using SLEs, but another aspect of these tools provides additional advantages to learners. Story and narrative are one of the oldest

and most widespread methods of storing and passing on knowledge. From the oral histories of ancient Greece to West African teaching stories, narrative has always played a major role in the transmission of information and life skills. In essence, it serves as a form of contextual anchoring that aids learners in the construction of learning structures. This principle is related to the cognitive psychology concept of the schema, which is a mental structure representing some aspect of the world and which organizes information to create coherent patterns of knowledge (Bower & Morrow, 1990; Bransford & Franks, 1971; Gagne, R. M. & Glaser, 1987; Schank & Abelson, 1977). Another concept from cognitive psychology also helps to support the idea that story influences comprehension and understanding. Bower & Morrow (1990) argues that coherent stories form connections between concepts, thoughts, events or ideas, and that the extensiveness of the connections between these elements determines both the centrality of the element in the story and the likelihood that it will be recalled later. Finally, (Bruner, 1991) argues that stories and narrative operates as "an instrument of mind in the construction of reality," and spelled out ten features of good narrative that help readers to create understanding of a story. In essence, his argument is that these features combine in the form of narrative story to create a gestalt that has a powerful influence on the ability of a reader to organize, categorize, and store information. Taken together, each of these multiple converging theoretical structures argue that embedding information in a story is an excellent way to increase the likelihood of encoding. Moreover, (Fiore, S., 2004) argues that the more central to the story the embedded information is, the more likely it is to be remembered. Therefore, embedding information in the story of an SLE which is critical to the successful use of the SLE should greatly increase the likelihood of retention.

Introduction Summary: The Electronic Alternative to Tradition

What is the best way for a learner to acquire semantic knowledge of the kind generally taught in school? Cannon-Bowers et al. (2003) have argued that several lines of research converge on the idea that interactive experiential learning anchored in context is both a fundamental human function and a process of creating knowledge based on transactions between a learner and their environment. From a basic research perspective, the underlying principles guiding the development of SLEs are well understood. Beginning with an overview of this area of research, I look here to briefly identify the foundations of learning theory and then move on to a brief examination of the characteristics of semantic memories and how these types of memories represent the bulk of the classroom knowledge. Having identified the theoretical underpinnings of learning and memory on which the more applied principles of the science of learning depend, I then move on to an examination of how research into the concepts of active learning and anchored instruction have led to the identification of simulation-based virtual experiential learning as a more effective foundation for learning than traditional "tell-test" approaches. Having established the pedagogical antecedents of SLE learning (i.e those similar to the functions of simulation) I turn next to those elements of SLEs that are shared with video games, including engagement, popularity, and hedonic value (enjoyability). Ultimately, the goal of this section is to discuss how the interactive nature of games and the story elements of SLEs separately facilitate learning in participants. The primary question remaining is how these two elements will interact to effect learning in participants using a SLE.

To that end, the present dissertation is intended to address a number of major questions related to features of learning in an SLE and, more broadly, to examine a number of theoretical

issues related to the use of SLEs. On an applied level, the study will address the issue of whether or not declarative knowledge can be successfully taught using a simple SLE which incorporates support for active learning in the context of a story. On a theoretical level, this work will examine a number of factors. First is the role of active learning, in which the material to be learned is processed or interacted with, versus passive review in improving learning and retention. While anecdotal and empirical evidence of the benefit of active learning exists (Barron, Schwartz, & Vye, 1998; Bransford, Brown, & Cocking, 1999; CTGV, 1997; Rao & DiCarlo, 2001), few studies have examined this issue in the context of games, but see Moreno & Mayer (2005) Secondly, the present work examines the effectiveness of a contextual story in improving recall of material presented in a SLE, an idea that has some limited theoretical and empirical support (Fiore, S., 2004; Gagne, R. M. & Glaser, 1987; Schank & Abelson, 1977). Finally, participants completed a subjective assessment of the SLE's hedonic value. This assessment fulfilled a number of purposes including assessing the correlation between enjoyment and learning, examining the potential connection between an individual's enjoyment of the SLE and their learning within it, and comparing enjoyment between more traditional learning methods and those used in SLEs.

Summary of Hypotheses

Six major hypotheses were tested in this experiment: First, the hypothesis that the presence of story in a SLE would improve retention for the learning material. Second, the hypothesis that interactivity would improve retention and recall of learning material presented in a SLE or other medium. Thirdly, the hypothesized interaction between these two constructs such

that learning would be maximized in the condition in which high levels of story and interactivity are present, and minimized in condition with low levels of both story and interactivity. Additionally, two hypotheses related to subjective perceptions and attitudes toward SLE learning were also examined. The emerging field of hedonomics argues that the hedonic value of a system (how pleasurable something is to use) is an important factor in how effectively it can be used (Hancock, P.A., Pepe, & Murphy, 2005; Murphy, Stanney, & Hancock, 2003). Accordingly, it was hypothesized that higher levels of narrative structure and interactivity should lead to improved affective response to the learning task, and would lead to higher self-assessments of learning.

CHAPTER TWO: LITERATURE REVIEW

Learning and Memory

As discussed above, SLEs represent a hybrid of games and simulations with a stronger focus on pedagogy, learning objectives, and the use of story to convey meaning and encourage participation. In this section I attempt to develop a train of logic which argues for the use of SLE's as learning tools. First, I briefly discuss the generally accepted categories of memory, and how each relates to material that might be learned through the use of a SLE. Then, I turn my attention to extant theories of learning, including brief overviews of the behaviorist, social, and cognitive views of learning and how they apply to learning in SLEs. I next quickly survey the state of the body of technology-centric theory collectively referred to as the "science of learning," which incorporates findings from the simulation and training domain, and which is most clearly embodied in the learning competencies identified by the National Science Foundation, and identify the place of SLEs in it. Following this, I briefly indicate how SLEs fit into the established theoretical framework commonly used by the education community, and then move on to a discussion of the features that SLEs share with both games and simulations and how they impact learning. Finally, I identify the unique advantages that games have over simulations and how SLEs can be designed to take advantage of these features while maintaining a focus on learning.

Types of Memory

A functional understanding of learning is critical to the development of SLEs, and such an understanding requires a working knowledge of the characteristics of different types of memories. Therefore, it is useful for us to draw distinctions between differing types of memory. The present work cannot hope to provide a comprehensive review of different types of memory. Readers are referred to Tulving (2002), Horton & Mills (1984), and Squire, Knowlton, & Musen (1993) for a more in-depth discussion of the distinctions between and among types of memory. The type of memory primarily relevant to this work is semantic memory, which is commonly used in the learning and recall of such factual information as names, formulae, and dates (Eichenbaum, 1997; Horton & Mills, 1984). Since the learning of such information is the basis of current educational practice, semantic memory holds a special place in learning research. More important for our purposes is the mechanism by which those memories are created, and understanding this will require that we begin with a short review of learning theory.

A Basic Review of Learning Theory

It is important to understand not only what kind of knowledge can be transmitted through the use of SLEs and similar tools, but how that knowledge is received, processed, stored and integrated into the learner's mental processes. In short, how does learning happen?

A review of the history of psychological research and theory yield three divergent but overlapping views of learning. The Behaviorist school focuses exclusively on the behavioral output of a learner (i.e. how do their actions and choices change as a result of learning) and relies heavily on classical and operant conditioning behaviors. In essence, one strength of behaviorism

9

is how it explains the way in which reward and reinforcement contribute to behavioral change (Harzem, 2002; Ormrod, 1999). From the perspective of this review, this is also a weakness in that behaviorism is more suited to explaining the formation of procedural and implicit memories than semantic memories. Since semantic memory is the type of memory most commonly associated with learning in the educational domain, this means that the behaviorist view has little to offer us in the context of this study. Additionally, while this view of learning is exceptionally good at explaining the ways in which non-human animals can be trained, and can even explain some large-scale human behavioral patterns, it fails to account for a number of major constructs that are critically important to learning: observational learning, in which an individual copies a behavior they have observed without having been trained to use it, and cognition, which is the human ability to reason and problem solve (Ormrod, 1999).

Because humans and some animals learn through observation, and because such strategies are not easily explained through a behaviorist view of learning, the Social Learning model (later called the Social Cognitivism model) was developed. This view of learning emphasizes a number of points. First, both observation of the strategies used by others, and observation of the consequences of those strategies can lead to learning in the observer. Moreover, learning may occur without an observable change in behavior, and cognitive features of learners play a role in learning (Bandura, 1989). Ultimately, social learning differs from behaviorist thought in that it attributes behavior to the decisions of thinking, learning individuals rather than purely as a conditioned response to an environment. While it does not apply well to the learning and retention of semantic memories, social cognitive theory does address the role of motivation in learning and the idea that learning can occur in the absence of behavioral change, two points that are critical to understanding learning in SLEs

As the role of cognition in learning has been explored further, the Cognitive view of learning has developed a great deal of support. Sharing many features with Social Learning, Cognitivism arose as a result of psychologists' efforts to explain the increasing complexity of learning behavior observed by researchers. Cognitive approaches to memory tend to focus on either the way in which information is stored in the mind, or how it is organized in memory. For some time, the Baddely-Hitch multipart model of memory has been widely viewed as providing the best explanation of how memory works (Baddeley & Hitch, 1974). It holds that information which enters the mind through any sort of sensory event is stored briefly in raw format, and information is drawn from this sensory storage and selectively processed in short-term (or "working") memory to refine and make sense of it. Following this, some information contained in STM may be retained for further processing, discarded, or encoded into long term memory (Baddeley & Hitch, 1974). The key component of this theoretical structure is that it allows for the impact of different learning strategies on memory formation and retention. In essence, it attributes to the learner the ability to choose to pay attention to information or to ignore or filter it out. This is a critical point, as it means that unlike older views of memory, the Baddely-Hitch model views the learner as an active participant in learning, and opens the door to consideration of the impact of such elements as motivation, strategy, and presentation of information on learning. Later refinements to the model include the work of Cowan, who argues that working memory is actually a subset of long term memory (Cowan, 2005), and Ericsson and Kintsch, who argue that working memory is actually more of a list of links to information in long term memory (Ericsson & Kintsch, 1995). Since, at the current date most research is focused on cognitive-based views of learning, and since cognitive theory is most adept at explaining the formation of semantic memory, it is this view that will comprise the bulk of this review, although

11

the other views be mentioned briefly when they can contribute a clearer view of an aspect of SLE- based learning.

Even among adherents of the cognitive view of learning, a number of different views of the process of memory formation exist, and can be widely grouped into those which emphasize relations between items in long-term memory and those which emphasize the characteristics of the means used to input events into memory. These two areas of specialty are commonly referred to as the "semantic networking" and "encoding" research domains. While these views are not in explicit disagreement, as they are aimed at different aspects of learning and memory, at the current time little effort has been made to link them either theoretically or empirically. Generally-speaking, semantic networking, or "relational" theories of memory, such as the organizational approaches which became popular during the 1960's and 70's, argue that the organization of items in memory is critical to retention and recall. Conversely, views of memory which emphasize the characteristics of individual input events (i.e. the conditions under which a memory is formed, along with the individual characteristics of the information that makes up that memory) stress the means by which information is stored (whether passively, as in a quick visual scan of a paragraph, or more actively by summarizing or paraphrasing text into a new form) as being the critical element in learning. Again, while these two viewpoints are not necessarily in opposition, little effort has been made to reconcile them, an effort which is well beyond the scope of the current work. Also beyond the scope of this work is a full review and discussion of the merits and specific predictions of these two disparate viewpoints into learning and memory. However, a short discussion of the characteristics of two of the more popular exemplars of these viewpoints could aid us in understanding how learning happens and how and why SLEs work.

Relational or Organizational Views of Memory

The "Meaningful Learning Theory" (Ausubel, 1963), is an example of a cognitive approach that focuses on the connections that learners make between new and previously-existing elements in their mental representations of knowledge. These elements and connections together form what is referred to as a semantic network (Ausubel, 1963, 1968; Ausubel, Novak, & Hanesian, 1978). These elements and connections are often represented by a tool known as a concept map, which represents individual pieces of information as objects which are connected to one another in a pattern which echoes the meaningful connections that learners perceive between them. This tends to produce the hierarchical but reticulated pattern shown in the concept map in Figure 1 below (Cantwell, no date; Novak & Gowin, 1984). Researchers in this area argue that learning occurs when individuals add additional elements of knowledge to their existing knowledge networks, and integrate them with other preexisting elements in the network. Research has shown an improvement in learning and retention (as opposed to traditional learning methods) when methods are used to encourage sematic network development (Ausubel, 1960; Buckley & Clawson, 1975). Further, studies using concept mapping techniques to examine learning performance have found that traditional "rote" learning methods produce inferior knowledge structures (Gonzalez, 1997).

Therefore, in this view, learning consists largely of identifying the ways in which new material can be linked to old material. Thus, when learning to recognize birds, for instance, one might link specific instances of birds (robins, sparrows, owls, eagles, etc) based on shared characteristics, and form links between them. For instance, one might group birds by defining characteristics; assigning songbirds (robins, bluebirds, nightingales, etc.) together, birds of prey

(eagles, hawks, owls, etc.) together, scavengers (vultures, buzzards, crows) together, and flightless birds (dodos, penguins, ostriches, etc) together. Or one might use a totally different scheme, such as size, or color. Such schemes commonly overlap, so that a crow might fall into a number of categories. Based on this view, many researchers have attempted use the complexity, extent, and exclusivity of these connections and groups to measure the level of knowledge held by an individual in one particular area. The creation of "mental maps," asking participants to link concepts together based on their internal sense of connectedness, is a staple of the study of expertise. I discuss expertise later in this section, and leave further discussion of this topic until then. In summary, relational views of memory, such as Ausubel's Meaningful Learning Theory, view learning as the process of linking items in memory to create coherent patterns that reflect useful or externally-accurate relationships. These views focus on how memories are organized, and not on how they are formed or generated.

Levels of Processing and Semantic Encoding

Another way of looking at learning and memory focuses on how memories are formed; that is, the process by which knowledge enters the mind and is encoded into memory. Such approaches commonly focus on the amount of cognitive processing that is performed on the material to be learned (Craik & Lockhart, 1972). Thus, material that is simply read, heard, or seen is much less likely to be remembered than information which is read, paraphrased, transcribed, and applied to complete a task or project. Moreover, learning strategies which require semantic processing, that is, those strategies that require information to be processed in such a way as to determine its meaning or interpret it in context, should have a greater effect on

14

knowledge retentions (Craik & Lockhart, 1972). Research evidence has consistently supported the hypothesis that semantic, or "deep," processing has a greater impact on memory retention than nonsemantic, or "shallow," processing (Horton & Mills, 1984). Researchers examining the levels of processing approach tend to focus on three key characteristics of individual processing events in working memory and their effect on learning and retention; elaboration, distinctiveness, and effort. A number of studies have identified improvements in memory for target words when participants were asked to elaborate on them (Bradshaw & Anderson, 1982; Stein & Bransford, 1979; Stevenson, 1981). In the context of learning games and simulations, the elaboration of material produced by learning and applying strategies to enhance performance in the game might be expected to operate the same way as elaborating on the meaning of a sentence. Thus, by linking the material to be learned to success in the game, learners can be encouraged to use and elaborate on information in memory. This can be expected to improve learning performance over traditional teaching methods, which rarely encourage elaboration and instead rely on the learner to study the material themselves at a later date (assuming they remember it or wrote it down).

A second characteristic of memory storage strategies is a (perhaps poorly-named) construct known as distinctiveness. When multiple items or pieces of information are presented in the same distinctive environment, recall for each element is improved. The same effect is observed when the items share a common distinctive trait. For instance, it would be easier to recall a set of target words that were presented in a unique sentence; for instance, the target words "fat" and "ice" could be more readily remembered if they were presented in the form of a sentence, such as: "the **fat** man fell through the thin **ice**." This finding has relevance for learning in games and other synthetic environments, as learning material can be presented in a specific

and meaningful context. This element is also related to the concepts of anchored instruction, situated learning, and context-dependent learning, discussed elsewhere in this work.

The third commonly cited element of the semantic coding approach to memory is the amount of effort expended during the encoding process. Cognitive effort can be defined as the amount of limited capacity available for processing that is required for a given task. Tyler et al. (1979) found a beneficial effect on memory of increased effort when controlling for levels of processing. Eysenck & Eysenck (1979) refined these findings by determining that semantic processing improved memory, but that it required more time and expenditure of cognitive effort to perform than non-semantic processing. They measured this expenditure in terms of "expended capacity," which was intended as a rough metric of the proportion of the total available amount of cognitive capacity expended on a particular task. Additionally, they found that elaboration of material only served to improve memory when it followed semantic processing; elaboration of material alone was not sufficient to improve memory in the absence of prior semantic processing. Thus, simple elaboration on a concept was only effective at improving memory when the concept being studied was also used in an applied manner beforehand. More relevant to us in this work, however, was the finding that expended capacity was far more closely linked to eventual recall performance than was time spent processing. In essence, the intensity and involvement of the learner in processing the material is more important than the time spent doing so. All of these findings have important implications for the way in which learning occurs in video games. In essence, activities (such as certain games) which require extensive semantic and elaborative processing of learning material are likely to produce more effective learning than more passive methods (such as receiving lecture).

The relational and levels of processing approaches inform different aspects of how SLEs work. In SLEs, story serves as a relational process, promoting meaningful connections between related principles, facts, and ideas. As the story progresses, meaningful relationships between concepts are revealed, helping to create a rich semantic network in the user. Such networks have been associated with improved performance on various tasks (Barnes & Clawson, 1975; Novak & Gowin, 1984). By contrast, the game format forces users to develop strategies for success through trial and error and simple hypothesis testing. This iterative process of developing and trying out new strategies serves as a type of repetitive elaboration. As discussed above, research into levels of processing suggests that elaboration is key to the deep understanding and encoding of information. Accordingly, it can be seen that SLEs utilize learning methodologies consistent with both the levels of processing and the relational views of learning. Story represents a relational process that leads to the formation of complex associative networks, while interactivity and game format represent and elaborative process that leads to greater depth and retention of knowledge.

Long term memory represents a network of related ideas organised as a **hierarchy** - where constructing bigger ideas from smaller ideas helps us remember those things we have learned.
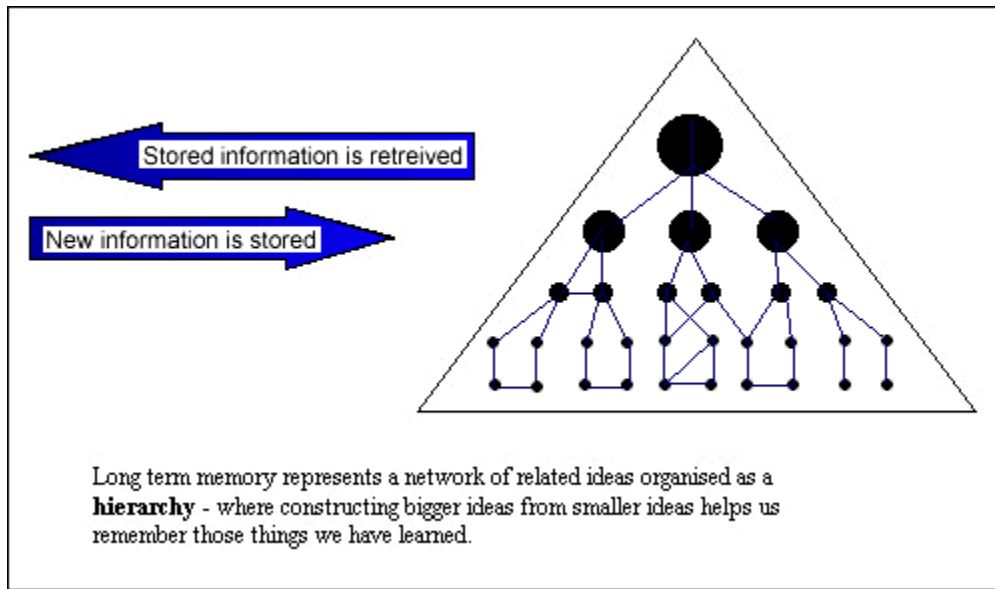
Figure 1 Hierarchical Structure of Memory Storage

Advantages of SLEs over Traditional Learning Methods

Having addressed the mechanisms by which learning occurs and the ways in which different types of knowledge can be stored, we turn to a discussion of the characteristics of SLEs which make them particularly good vehicles for learning content. I argue that SLEs represent a highly-effective means of generating virtual experiential learning, and that this construct is the natural convergence point of a large number of concepts drawn from the last fifty years of research into learning, including active participation, contextual or anchored learning, and the primacy of experiential learning.

Active Participation in Learning

The first important theoretical argument for use of SLEs revolves around the efficiency of active participation in learning and the suitability of SLEs to this type of learning. A number of works have examined this issue (Anderson & Schunn, 2000; Barron, Schwartz, & Vye, 1998; Chi, 2000; Chi & Bassok, 1989; Chi, Slotta, & de Leeuw, 1994; CTGV, 1997; King, 1992; Novak & Gowin, 1984; Rosenshine, Meister, & Chapman, 1996) and generally found that increasing the learner's active involvement in the learning produces better results. Positive effects on learning as a result of active engagement in the learning material or task have been observed in areas as diverse as spatial and geographical knowledge (Wilson, Foreman, Gillett, & Stanton, 1997), vocabulary skills (CTGV, 1997; Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers, 2006), vehicle operation (Jentsch & Bowers, 1998), painting skill (Martin, 2006), declarative knowledge about human anatomy (Rao & DiCarlo, 2001), and medical knowledge (Bushby, 1994). The key to active learning is the promotion of learner interaction with the material (Bransford, Brown, & Cocking, 1999). In essence, interactivity could be said to be the governing attribute of a system designed to promote active learning. It is therefore expected that the increased interactivity of SLEs relative to traditional learning methods will contribute to a more active approach to learning on the part of participants which will result in improved knowledge of the material in question (Rao & DiCarlo, 2001; Vakil, Hoffman, & Myzliek, 1998).

Feedback

The ability to deliver feedback in a timely and appropriate manner is also a strength of SLEs, and represents an important advantage over traditional learning methods The study of feedback in learning represents an enormous and diverse body of research (Azevedo & Bernard, 1995; Schmidt & Bjork, 1992), and is far beyond the scope of this work. Moreover, feedback is a characteristic of most, if not all, learning systems, and is therefore hardly unique to the study of SLEs. For our purposes, I simply accept the largely uncontested view that feedback is critical for learning (Gagne, R., Briggs, L. & Wager, 1992; Gagne, R. & Driscoll, 1988; Ilgen, Fisher, & Taylor, 1979; Komaki, Heinzmann, & Lawson, 1980), and move on. However, one point that will become important to us later in the discussion is the viewpoint that immediate and accurate feedback have been shown to improve performance (Azevedo & Bernard, 1995; Kulik & Kulik, 1988).

Anchored Instruction

If learners are to take full advantage of such virtual experiential learning, it is necessary that the learning events the experience be anchored in a specific context (CTGV, 1990, 1993). This context informs all of the scenarios or learning events in which a learner participates, and provides a sense of continuity and realism that is critical to good learning. Thus, learners are either explicitly or implicitly placed in the context of a problem-based story and are given an authentic role to play. They then investigate the problem and develop solutions to it while identifying and taking action to fill gaps in their knowledge of the subject area. Bransford, Sherwood, Hasselbring, Kinzer, & Williams (1990) identified a number of principles of good

design with regards to anchored instruction, which include: a realistic task or event, a problem anchored in the context of that task or event, the presentation of multiple scenarios, usually in a narrative format or story with embedded data, and knowledge structures that are highly generalizable to other situations. Learners utilizing and anchored instruction approach are expected to take ownership of the problem by identifying with the problem or role, and actively working to solve the problem by dividing it into interconnected sub-problems and developing solutions for them. The expected result is a deeper development of knowledge structures than that seen using traditional teach-test paradigms (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). One area of education to recently embrace the anchored instruction approach through the use of case-based learning vignettes is the medical educational establishment (Bushby, 1994; Friedl et al., 1996; Kwan, 2002).

The Anchoring Role of Story

Story embodies a particularly useful form of contextual anchoring. Because the use of story and narrative is the oldest and most widely understood way of storing and communicating knowledge, it is natural to consider its role in the development of SLEs (McDaniel, 2004). Bruner (1991) argues that, in fact, story is the means by which we construct reality. Accordingly, I should expect that a coherent and relevant storyline should improve learning and retention of knowledge in a SLE. This dovetails nicely with the concept of anchored instruction, discussed at length above. This view of story and narrative as a way of interpreting perception is supported by cognitive work on the human dependence on the use of schemas to encode meaning (Bower & Morrow, 1990; Bransford & Franks, 1971; Gagne, R. M. & Glaser, 1987; Schank & Abelson,

21

1977). Other lines of evidence from cognitive science converge on the idea that story influences comprehension. Bower & Morrow (1990) draw from relational views of memory in making the argument that coherent stories form connections between concepts, thoughts, events, and ideas, and that the extensiveness of the connection to and from any single concept determines not only its centrality to the story, but also the likelihood that it will be encoded and recalled later. With regard to Bower & Morrow's work (1990), Fiore (2004) argues that "this notion of the inherent connectivity of story is important from the learning standpoint and fits with theoretical notions of knowledge integration in complex learning environments." Thus, story provides a structure which encourages the formation of semantic networks among concepts inherent in the story. Therefore, by embedding information to be learned into the context of a story the likelihood of information encoding can be improved. When the information embedded in the storyline of an SLE is also critical to success in the SLE, it should be even more likely to be remembered.

This notion comes with a notable caveat. Stories and schemas may represent a two-edged sword with regards to memory. Learners are more likely to recall the gist of a story than its details, and often change, drop, or add ideas or elements to make the story conform better to their internal schemas. This phenomenon was first identified in (Bartlett, 1932), and later reviewed and confirmed by other researchers (Schacter, 1996). The clearest demonstration of this phenomenon comes from (Bransford, Barclay, & Franks, 1972), who found that participants routinely remembered stories incorrectly when the incorrect version more accurately fit their schema-based expectations. These works are commonly cited today in reviews and discussions involving implanted or recovered memories.

Another potential concern arises from the potential tension or opposition between the inherently limiting and dispository nature of traditional narrative as embodied in all forms of

22

print literature and even the predecessor of such materials, the oral narrative or story. While these differ in the medium of their presentation, they are identical in their approach to delivering content. A bard of Homer's time, in the fourth century BC, would certainly have recognized the themes and characters in James Joyce's Ulysses as comparable to those of his own time, and might even have recognized the story, if only he could have read it. The emergence of interactive media, however, has created a genuinely new dynamic between author and reader – and with it a challenge to traditional forms of story. In printed or oral stories, all the power to construct or change the story rests in the hands of the author. In interactive digital media, however, and in particular in the case of video games, a significant measure of the decision making power is held by the "reader," or in this case, the player. As a result, in such forms of media there always exists a dynamic tension between the freedom of the author to shape the narrative and the freedom of the player to choose the actions of the protagonist. This effect is discussed at length elsewhere (Ryan, 2001) (Jenkins, No Date), but for our purposes, is sufficient to simply point out that this dynamic tension means that we must walk a fine line with our narrative choices – we must ensure that we provide enough narrative structure to drive the story, while retaining enough leeway for the player to make what (appear at least to be) meaningful choices.

Further, in this case, the power of narrative is also constrained by the unwritten rules of the educational establishment and the age of the intended audience. For this reason, it was necessary to design a story without significant levels of violence or serious danger of violence. Since most good storytelling depends on violence, or at least conflict, this presents a major challenge for the creators of the story. We will discuss why this is important to the present study later in this work.

Because they draw on concepts from Anchored Instruction, Expertise, and Scenario Based Training, and utilize effective learning strategies derived from learning theory, SLEs represent a proven method allowing learners to rapidly and repeatedly experiment with different problem solving approaches while gaining experience in a system or environment without being exposed to the real world consequences of mistakes or failures. Additionally, SLEs have the potential to make such learning enjoyable, a feature which both distinguishes them from and makes them superior to simulations.

Experiential Learning and Virtual Experiential Learning

Experiential Learning

These lines of evidence lead inexorably to the conclusion that learning should be conceptually anchored in a meaningful context for learners. That is, learning should occur in the context from which the knowledge derives, or in which it is used. One way to accomplish this is by promoting experiential learning, that is, learning which takes the form of real-world (or simulated real-world) experience. Experiential learning is commonplace in childhood, and occurs constantly throughout life. As such, it has been characterized as a pervasive and fundamental form of knowledge development (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 2000). Experiential learning, being an interaction between a learner and an environment or system, illustrates the essential point that learning is a transaction between the learner and their environment (Jonassen & Grabowski, 1993; Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 2000). Learning, therefore, should not be characterized by outcome (that is, by performance on a test),

but rather conceptualized as a process, whereby concepts are distilled from an experience and stored in the context of that experience (Jonassen & Grabowski, 1993).

Accordingly, the use of systems, such as SLEs, which provide learners with the opportunity to experience the material to be learned in the context of an interactive, meaningful, and firsthand environment would be an asset to improving learning methods. Such systems would be able to help learners experience large numbers of examples of problems and cases which they can integrate into their mental knowledge structure.

Virtual Experiential Learning

As the technology on which virtual experience is based has improved, so to has the ability of designers to create virtual environments which are psychologically compelling and valid. Despite some ongoing problems (including motion sickness) the recent history of VEs has been one of increasingly complete and immersive virtual experience (Stanney, 2002). The logical outcome of this type of virtual experience is the potential for learners to engage in "virtual trial and error" learning. In essence, real world lessons and experience without the potentially negative or even dangerous consequences of real world failure. This is not a new argument, nor is it a capability unique to virtual experience. In essence, it forms the basis of the theoretical justification for a number of learning paradigms and technologies, including simulation, scenario-based training, and the military's venerable field training exercises. The basis of learning using virtual environments is the provision to the learner of a large number of simulated cases to observe and with which they can interact. Such extensive virtual experience is an ideal tool for developing and reinforcing knowledge structures. The second vital element of this type

of learning is that the learner is in control and can make choices and decisions in a simulated real world environment, and then observe the outcome of those decisions. Over time, learners gain an increased understanding of how to make better decisions by exploring actions and consequences in an interactive environment.

As we have seen, the nature of SLEs lends itself to active exploration of the learning domain. Active participation in learning has been previously identified as a key element in the development of expertise, which is by nature anchored in context. Synthetic experience, such as that seen in SLEs, is a highly effective way of enabling learning in context to speed the development of expert knowledge. All of these lines of argument taken together lead to the conclusion that the most effective means of learning are experiential, active, and anchored in context, and that SLEs and related technologies offer the possibility of virtual experiential learning.

As mentioned earlier, all of the advantages of synthetic learning environments that have been discussed so far are not unique to this type of learning experience. Simulations share many of these characteristics, as do other types of active learning paradigms. However, what makes SLE's distinct from and superior to these systems are the advantages that the addition of game elements brings to their ability to engage and immerse learners. *Engagement* is a term discussed frequently in the context of game design, and the creation of an engaging and compelling experience is a defining characteristic of games. The ability to foster an experience of engagement with the system is an advantage specific to games (and, therefore, to related technologies such as SLEs).

The Role of Engagement in Synthetic Learning

One of the primary advantages of digital games and SLE's over traditional training systems is the engaging and motivational effects well-designed games have on their users. If a learning game is engaging, users are likely to keep using it, and will try to be successful in achieving their goals in the game. By continuing to play and to strive to achieve within the context of the game, the player is more able to effectively learn the material the game tries to present. One important issue in maintaining engagement is making the game "fun." A number of areas have been identified as important in fostering game enjoyment, including challenge, fantasy, and curiosity (Malone, 1980). "Challenge" refers to the difficulty experienced by the learner in achieving the game objectives. Too little challenge and the learner may become bored, too much and they can become frustrated. Either way, the learner is unlikely to want to continue using the game. Moreover, these opposite states of boredom and frustration may be viewed as representing suboptimal levels of arousal, and like all hypo- and hyper-stress states, are likely to result in decreased learning efficiency and performance on the learning task (Hancock and Warm, 1989). Decreased performance on the learning task is likely to limit the ability of the game to communicate the material to be learned.

A second element in engagement is "Curiosity." In order to engage users, the game must appeal to their curiosity about the game world. The auditory and visual effects of the game must serve to draw the user in, and support the fantasy which the game is attempting to create. In the context of SLEs, it is vital that the game encourage investigation of the material to be learned either through appealing visual or auditory feedback or by rewarding learners with some item, skill, or other "goodie" which is valuable in the game context.

The concept of "Fantasy" refers to the emotional appeal of the system. In order to engage users, the SLE must help to create an emotionally-appealing fantasy for the user, preferably one which is intrinsic to the skill or knowledge the game is trying to teach or provides a helpful metaphor for the skill. For instance, a game designed to teach basic economics to high schoolers might cast the user as a young entrepreneur starting their first business while still in high school. Fantasy-supportive and engaging feedback in this case might come in several forms: the growing business infrastructure and bank account of the player, increased options for interacting with the game (like the ability to hire better or more interesting helpers, acquire new types of businesses, or run for public office), or the increased reputation, skills, and popularity of the player's game character.

Hedonic Value and SLE Use

Ultimately, when discussing the advantages of game-influenced SLEs over similar technologies such as simulations, I cannot neglect a simple assessment of the enjoyment of the experience. The hedonic value of the video game experience is necessarily very high, otherwise game players worldwide would not spend more money on games annually than on all Hollywood movie box office revenues combined. Regardless of whether or not engagement is the means by which the pleasurable experience of game playing is achieved, the simple fact that it *is* enjoyable has a significant impact on the amount of time players voluntarily spend engaged in the interactive experience. The emerging field of Hedonomics is defined as the "branch of science which facilitates the pleasant or enjoyable aspects of human-computer interaction."

Previous research has shown that an enjoyable and pleasurable experience is critical to continued interaction with a learning system, an by extension, to learning (Hassenzahl, 2003; Wensveen & Overbeeke, 2003). Moreover, positive affect, enjoyment and pleasure has been linked to learning and cognitive flexibility (Brickman & Campbel, 1971; Isen, Daubman, & Novwicki, 1987; Murphy, Stanney, & Hancock, 2003). Additionally, the hedonic value of a system is a major motivating factor in encouraging its use (Csikszentmihalyi, 1990; Kahneman, Diener, & Schwarz, 1999; Kippendorff, 2004; Ryan & Deci, 2001). Therefore, one advantage that games, and by extension, SLEs have over traditional simulation is their hedonic value to learners.

One possible cause of the high hedonic quality of games is the concept of "Flow," pioneered by Mihaly Csikszentmihalyi. Flow is a subjective state characterized by a loss of self-consciousness, a distorted sense of time, and a sense of complete personal control over the situation, which leads a general feeling of absorption into the task at hand, coupled with a sense of effortlessness of action. In essence, a person experiencing flow feels that their awareness is narrowed to the activity itself, a perceptual phenomenon known as action awareness merging (Csikszentmihalyi, 1975). A number of conditions have been identified which help to cultivate the experience of flow, including clear goals, concentrating and focusing on the task at hand, the presence of a good balance between ability and challenge, and an intrinsically rewarding task (Csikszentmihalyi, 1990). Since the ideal gameplay state parallels the flow experience closely, SLEs may benefit from the positive hedonic influence of flow.

The Ubiquity of Engaging Media and the Popularity of Video Games

Aside from their appeal to individual users, it would be a mistake to discount the importance of the popularity of video games when arguing for their usefulness as learning tools. The Entertainment Software Association claims that 75% of heads of households play some form of computer or video game, and that the average age of gamers has risen to 30. What is somewhat more remarkable is that 19% of people over the age of 50 play games as well. While the type of games played by different age groups may vary, two telling statistics indicate the long-term prospects of the gaming industry. First, the average adult gamer has been playing video games for 12 years or more, and second, over 50% of current gamers expect to be spending as much or more time gaming 10 years from now as they do today. Taken together, these two statistics suggest that this form of entertainment is likely to continue to play a significant role in the lives of people of all ages.

The gaming industry still considers their target demographic to be males between the ages of 18 and 40. However, the percentage of women involved in gaming has increased steadily. Currently, it is believed that an estimated 43% of all gamers are women. Further, this statistic is similar for both online and single player games, indicating that female gamers have similar playing habits to their male counterparts. Another interesting comment of the ubiquity of gaming across genders and ages is the finding that 9 of the 12 games that sold over a million units in 2004 were rated "E" for "Everyone" or "T" for "Teen" by the ESRB. This may suggest that the stereotypical teenage "blood and sex" game player is no longer the primary demographic of game users. Accordingly, digital game based technologies now reach more users than at any time previously, making SLEs more useful now than at any previous time.

Defining the Outcome and Understanding of Learning

NSF "Core Learning Competencies"

Based on a review of several decades of learning research, the National Science Foundation has established a number of core competencies for learning, which are important to an understanding of the way in which learning occurs, and provide direction to the present work (Donovan, Bransford, & Pellegrino, 1999). First, a foundation of declarative or factual knowledge must be established in the learner, which will form the basis of further knowledge structure development. Learners must then learn to organize facts and ideas into the context of a conceptual framework. This can be assisted by the use of anchored instruction. Anchored instruction has been defined as "a paradigm which is focused on the development and implementation of interactive technology. Its aim is to provide realistic contexts as *anchors* to encourage active knowledge construction and the solution of complex, realistic problems by learners. Anchoring concepts, which are already present in the cognitive structure, are related to new concepts before determining the meaningfulness of the new learning material (van den Aardweg & van den Aardweg, 1993).

Learners must also develop the capacity to organize knowledge in ways which facilitate retrieval and application. This form of internal knowledge organization allows the development of a system for storing information and retrieving it under conditions where it is of use. This concept is distinct from the use of the term "knowledge organization" to define external systems of knowledge storage and retrieval, such as those used in libraries. While the analogy to

cataloging and storage systems is apt, it suggests a type of artificial organization which has not been shown to be present in mental knowledge organization systems.

Another competency important to learning is the ability to integrate new concepts into pre-existing conceptions of how the world works. The development, updating, and maintenance of accurate and complete mental models plays a critical role in the development of expert knowledge (Schumaker & Czerwinski, 1992). Therefore, fitting new facts, concepts, and ideas into a pre-existing mental model is vital to the learning process.

Finally, the NSF identified the ability to take control of learning by defining learning goals and monitoring progress in achieving them as important to learners. This is likely to be a particularly hard skill for many learners to master, incorporating as it does elements of metacognition and self-regulation.

The use of SLEs can address many of the challenges associated with the learning competencies associated with the NSF. Because SLEs provide a context and story in which learning material is embedded, they provide a means of delivering anchored instruction. The integration of new concepts into existing learning structures can be accomplished effortlessly in SLEs, simply by expanding the virtual world to encompass the new material. Since new and old material is be used in conjunction in such a system, new material should eventually become seamlessly integrated with older, existing knowledge structures and mental models. While SLEs do not necessarily force users to engage in metacognition, the ability to derive ongoing measures of performance available to users and instructors alike allows for effective and instantaneous measures of learning and progress. As discussed above, immediate and accurate feedback have been shown to improve performance (Azevedo & Bernard, 1995).

Metaknowledge Regarding Learning Efficiency and Metacognitive Bias

When examining a the transaction between the learner and the learning material, it is important to consider the issue not only from the perspective of what is being learned, and how well, but also what the learner *believes* they are learning, and how well they believe they are learning it. Knowledge about one's own knowledge is us generally referred to as "metaknowledge," from ancient greek "μετά," meaning "beyond," and the modern English noun "knowledge," the meaning of which is obvious (or not, depending on whether one is a scientist or a philosopher). Regardless, it is important to consider the role of metaknowledge in the process of learning, as the way in which a learner chooses to use the information they learn is unavoidably linked to their understanding both of the qualitative and quantitative nature of their knowledge.

The quality of a learner's metaknowledge can be assessed through the use of a Metacognitive bias score. A Metacognitive bias score is generally obtained by taking the average of the z-transformed prediction minus the z-transformed performance of each participant (Fiore, S., 2007). Therefore, it represents an average normalized difference score between how well participants thought they learned the material and how well the assessment suggested that they actually did learn it. When dealing with metacognitive bias, positive scores indicate overconfidence (the participant thought they did better than they did) and negative score reveal underconfidence (participants believe that they did not do as well as the assessment indicated they had), and a score of 0 would indicate a perfect correlation between predicted and actual performance (Fiore, S. M., Cuevas, Scielzo, & Salas, 2002; Koriat & Bjork, 2005). Since participants were never given feedback on their performance on the assessment (and in fact,

made their prediction of learning before they took the assessment) their estimate of performance was based only on their subjective experience while undergoing the learning condition.

Comparison of Presentation Conditions to Real World Learning Practices

If the present work is to contribute significantly to the body of knowledge on SLE-based learning, it must relate on a practical level to the domain of primary and secondary education. If the results of this study are to have any impact whatsoever on the day-to-day work of educating students, then the experimental manipulation used must be shown to relate in some meaningful way to real-world learning practices. Therefore, a brief analysis of each experimental condition and how it relates to current educational practice is in order.

In essence, the four conditions also mimicked a number of instructional information presentation types commonly used in educational settings. The no story, low interactivity condition is highly similar to the traditional "back-to-basics" instructional method, in which material is presented as a list of information in a plain text format. Students are expected to passively absorb and memorize the information, possibly using a number of simple mnemonic devices to aid in encoding or recall. Another example of this method is the use of some types of filmstrips or videos, in which a student passively absorbs information from a visual or multimedia presentation (this only applies to those works in which not attempt is made to provide story or context for the information.

The no story with high interactivity condition is similar to instructional methods in which information is presented in a way that allows the student to interact with the material but does not provide specific context for it. One example of this method that is commonly used in the

education domain is the use of "manipulatives," or physical items which are brought in to a classroom or learning environment to be handled or seen).

The story with low interactivity condition is similar to instructional methods in which learners are exposed to a story which is intended to present factual information in context. The use of historical novels, biographies, and story-based films and videos in an educational context is typical of this type of presentation.

Finally, the low story with high interactivity condition is similar to most existing "edutainment" model learning games. While popular with parents and teachers, the evidence of improved learning using these systems is limited. Having addressed what the real-world analog of each condition, let us now turn to whether or not each hypothesis was confirmed.

Story Elements with High Interactivity Present

There are two learning conditions in which the learning material is presented in the context of a story. In the "Story with Interactivity" condition, the full Mundymod for NWN is used to expose the learner to the learning material. Participants experience a story designed to support and embed learning anchored in the context of the historical time and place of the underground railroad through the interactive medium of the SLE.

Story Elements with Low Interactivity Present

In the "Story with low Interactivity" condition, participants experience a story through the passive medium of text. Instead of driving character interaction and plot development

through interaction with the game interface, participants read text-based descriptions of these events.

Story Elements Absent, High Interactivity

There are two learning conditions in which the learning material is presented outside of the context of a story. In the "No Story with interactivity" condition, participants interact with a limited SLE in which their actions reveal the learning material in an interactive manner, but there are no context or story elements present.

Story Elements Absent, Low Interactivity

In the "No Story with low interactivity" condition, participants experience the learning material through passive textual presentation. Learning material is be presented in the form of a "fact list," with no context or story elements.

CHAPTER THREE: METHODOLOGY

Participants

92 Participants (68 Males, 22 Females) with a mean age of 21.8 years were drawn from one introductory Principles of Digital Media class and completed one of four conditions on one of five laptop computers over a six-day period. 12 participants (11 Males, 1 Female) didn't complete the experimental task, failed to answer a majority of the questions, or reported significant perceptual learning disabilities and were dropped from the task, leaving 80 Participants (59 M, 21F) with a mean age of 21.5 years. A power analysis based on Cohen's power tables (Cohen, 1988) assuming df = 3, Power = .80, and α = .05, and an effect size of .20 indicated a recommended n of 69. Since our final number of participants was well above this number, we can claim with confidence that our sample size was sufficient to refute the null hypothesis, assuming that an effect existed to be identified. A multivariate MANOVA of demographics by condition indicated no significant correlations between any of the collected demographics and condition, indicating that random assignment was preserved.

Apparatus

The Mundymod SLE was developed using money from a grant from the Institute for Simulation and Training. The mod itself was adapted from a COTS computer game called Neverwinter Nights ®, by Bioware. It was designed to be a vehicle for educating students about the history of the underground railroad and to showcase historical artifacts in their historical

context. The mundymod was developed with the assistance of students from UCF's school of Film and Digital Media, and overseen by a multi-disciplinary research team from UCF's Departments of Psychology, Philosophy, and Film and Digital Media.

The Mod itself tells the story of a slave on a North Florida indigo plantation in 1853 who decides to escape from bondage and flee to freedom. The original mod covers the initial escape of the protagonist from the plantation, including making contact with a "conductor" on the railroad. For the purposes of the present experiment, a number of versions were developed. These included a version in which the story was largely removed but the characters were retained. Instead of speaking their regular dialog, they simply speak a list of the historical information that was originally part of the complete story. A transcript of the story is included in Appendix F.

The learning material in the game was drawn from elementary and secondary school textbooks, and chosen on the basis of inclusion in the Florida Sunshine State Standards (FSSS) from the Florida Department of Education (FDOE). A list of the learning items in the mod is provided in the attached appendix A.

<u>Design</u>

2 x 2 factorial design was used in this study. Independent variables were story presence or absence and higher or lower levels of interactivity in learning material presentation. A post-experimental test of historical knowledge was used to assess learning and served as the primary dependent variable. Additionally, because all of the learning material in every condition was presented in written form and individual differences in verbal ability were to be expected in the

participant population, the Guilford-Zimmerman Vocabulary Test (Guilford & Zimmerman, 1947)was administered to participants for use as a covariate.

Learning Conditions

This study was designed to examine the effect of presentation method on learning, and involves four presentation conditions, distinguished by the presence or absence of a contextual story and the presence or absence of computer-based interactivity. Since interactivity and story/context are both critical components that distinguish SLEs from other learning methods, it is necessary to assess the effects of both of these constructs separately and in combination. Therefore, both story and interactivity are manipulated factorially so that the main effects and interactions can all be observed.

Due to the inherent differences in the mode of presentation used in the study, it is impossible to use the regular convention of standardizing exposure time to the material. This is because a participant in the full-interactivity conditions must simply spend more time interacting with the interface of the SLE. This means that there is an unavoidably larger time necessary for the user to complete these conditions. However, it is possible to ensure that participants in all conditions receive the same *number* of exposures to the material. Thus, a participant may spend 10 minutes interacting with the treatment in the full-interactivity, full-story condition, versus only 5 minutes in the no-story, no-interactivity condition, but both participants will be exposed to the learning material itself the same number of times (and for roughly the same amount of time, not accounting for individual differences in reading speed). If time in each condition *were* held constant, as is the custom in most learning studies, this would translate to significantly larger

review times for participants in the non-interactive conditions, and thus create a confound between conditions on exposure time with regards to the material. Therefore, instead of holding time constant across conditions, as is traditional in learning studies, the present study hold exposures to material constant across conditions, which is necessary to avoid confounding review time with presentation mode.

Story Elements with High Interactivity Present

There are two learning conditions in which the learning material is presented in the context of a story. In the "Story with Interactivity" condition, the full Mundymod for NWN is used to expose the learner to the learning material. Participants experience a story designed to support and embed learning anchored in the context of the historical time and place of the underground railroad through the interactive medium of the SLE.

Story Elements with Low Interactivity Present

In the "Story with low Interactivity" condition, participants experience a story through the passive medium of text. Instead of driving character interaction and plot development through interaction with the game interface, participants will read text-based descriptions of these events.

Story Elements Absent, High Interactivity

There are two learning conditions in which the learning material is presented outside of the context of a story. In the "No Story with interactivity" condition, participants interact with a limited SLE in which their actions reveal the learning material in an interactive manner, but no context or story elements will be present.

Story Elements Absent, Low Interactivity

In the "No Story with low interactivity" condition, participants experience the learning material through passive textual presentation. Learning material will be presented in the form of a "fact list," with no context or story elements.

Procedure

Upon arrival, participants completed an informed consent form, biographical questionnaire, and historical knowledge pre-test. They then interacted with one of two versions of a computer game or one of two text documents. Each of these experimental conditions contained the same historical information. Following interaction with the document or game, participants completed the historical knowledge post-test. They were then debriefed, thanked for their participation, and released. After they departed, their information was stored for later analysis, with the informed consent (the only documentation containing their name) stored separately from the rest of their personal and study-related information.

Measures

The test included information on American history related to the underground railroad, and will consist of two sections, the first a free-recall question asking the participant to recall all the information they can about the experience. The second section will consist of recognition and recall questions assessing the historical knowledge of participants relating to American history information. Some of the information will have been presented in the treatment, and some will not. The questions based on information which was not presented in the study will be used as a baseline assessment of the participant's historical knowledge on this topic. Each of the four conditions (N = 20) will be between subjects.

Historical Knowledge Survey

Following the completion of the learning condition, the ability of the participants to recall information presented during the learning phase was assessed using a historical knowledge survey. This test consisted three sections. The first section contained an open-ended free-recall question, which asked the participant to write down everything they recalled from the experience. This section was scored by checking each participant's answer and identifying correct references to learning items embedded in each of the treatments. Additionally, inferences drawn from the learning points (for instance, inferring from the information about hiding and being pursued by officers of the law that escaping from slavery was dangerous and illegal) were also be identified and scored.

The second section consisted of 10 explicit questions based on learning material embedded in the SLE plus 3 control questions about slavery, antebellum and civil-war era

42

history, and the American south. The purpose of the second set of questions is to assess the

baseline knowledge of the participant on the topic of African-American history. These questions

were divided into recognition and recall questions and operationalized using a traditional

multiple-choice or fill-in-the-blanks/short answer test format.

Every section of the test was completed by each participant in order and was placed to the

side following completion to prevent backtracking. A copy of the test is attached in Appendix C.

Grading Procedures

Participants' responses on the historical knowledge survey were graded against a pre-

generated answer key, and graders were never aware of the experimental condition to which the

participant was assigned while rating their responses. As discussed above, there were three types

of questions arranged in three sections on the test. The first section, the free response area, was

assessed by determining how many of the 25 learning points were mentioned in a correct

context. Participants received full credit for recalling a learning point if they remembered the

proper name of the person, place, thing, and if they linked it to the appropriate concept. If an

answer included the correct name but so in such as way as to indicate that the participant did not

correctly learn the material (for instance, by identifying the underground railroad as an actual

railroad running underground) then they received no credit for their answer. Correct answers on

the next section, which were fill-in the blanks/short answer questions received credit on the same

criteria. Correct answers on the third section, which consisted of multiple-choice questions, were

assessed on the basis of whether or not the participant circled the best answer to the question.

Since it was determined that the unprompted recall of learning material represented the most thorough recall of learning, three points were added to a participant's recall score for getting a question right in the first section. Since it was possible for participants to get a maximum score of 25 on this section (if the participant identified every learning point correctly in this section), the highest possible score on the test was 75/75. Correct answers on the second section, which tested the ability to recall a particular piece of information when prompted, added two points to a participant's score. Choosing the best answer on the multiple choice section, which assessed the participant's ability to recognize the proper answer when presented with it, added only one point to a participant's score.

CHAPTER FOUR: FINDINGS

Historical Knowledge Survey Results

In the following section I discuss the findings related to the Historical Knowledge Survey. In order to test hypotheses 1-4, a 2 (story) x 2 (interactivity) ANCOVA was performed on weighted historical knowledge score using performance on the Guilford-Zimmerman vocabulary survey as a covariate. As seen in figure 2, a main effect of story condition was observed, $F(4, 75) = 4.075$, $p < .05$, $\eta^2 = .05$, such that, when collapsed across interactivity conditions, participants who experienced the material in high-story conditions ($M = 34.04$, SE = 1.64) performed more poorly than those who experienced the material in low-story conditions ($M = 29.27$, SE = 1.69). As seen in figure 3, there was no main effect of interactivity, $F(4,75) = 1.35$. As seen in figure 4, A significant interaction was also observed, $(4, 75) = 4.425$, $p < .05$, $\eta^2 = .056$, such that participants in the high-interactivity learning conditions who experienced the low-narrativity condition ($M = 36.56$, $SD = 11.18$) performed much better on the survey of historical knowledge than those in the high-story high-narrativity conditions ($M = 29.95$, $SD = 8.85$). Descriptive statisitics for performance on the Historical Knowledge survey appear in Table 1.

Table 1

Descriptive Statistics for Historical Knowledge Scores

Story Learning Condition	Interactive Learning Condition	Mean	SD	N
Absent	Absent	31.9	11.3	20
	Present	36.6	11.2	21
	Total	34.3	11.4	41
Present	Absent	31.2	10.9	19
	Present	27.0	8.8	20
	Total	29.0	10.0	39
Total	Absent	31.5	11.0	39
	Present	31.9	11.1	41
	Total	31.7	11.0	80
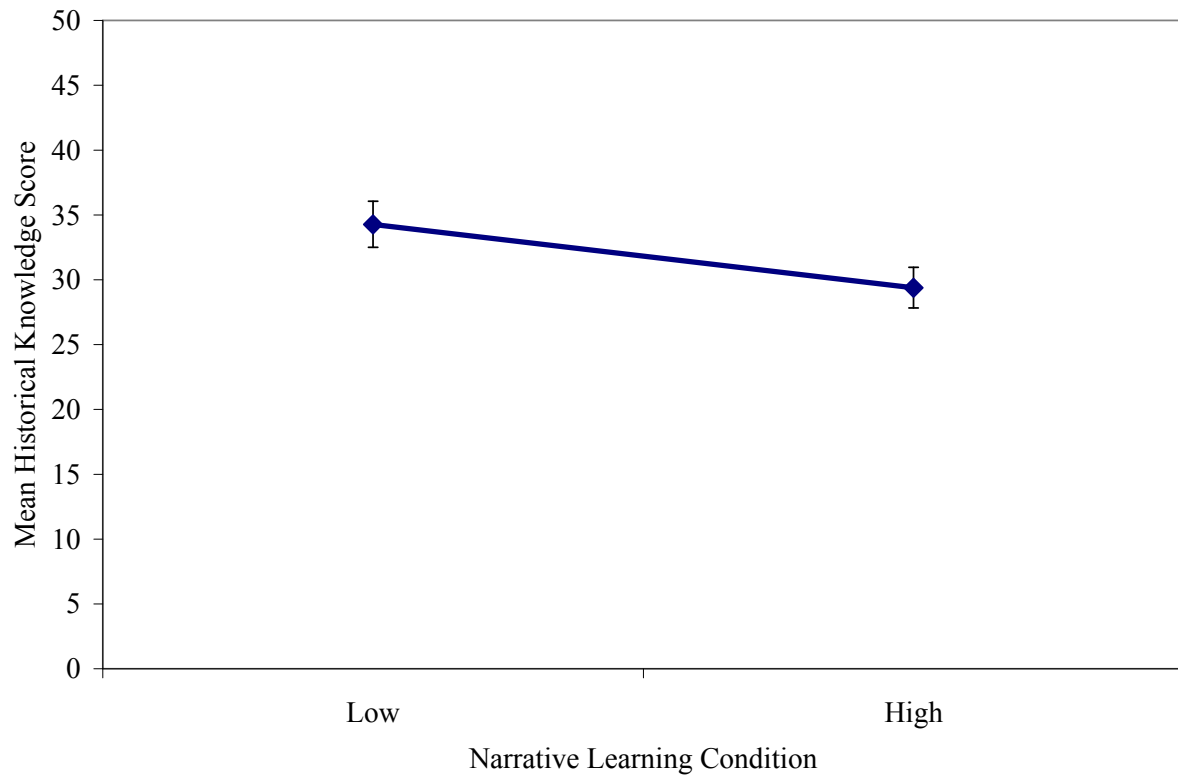
Figure 2 Mean Historical Knowledge Scores by Story Learning Condition
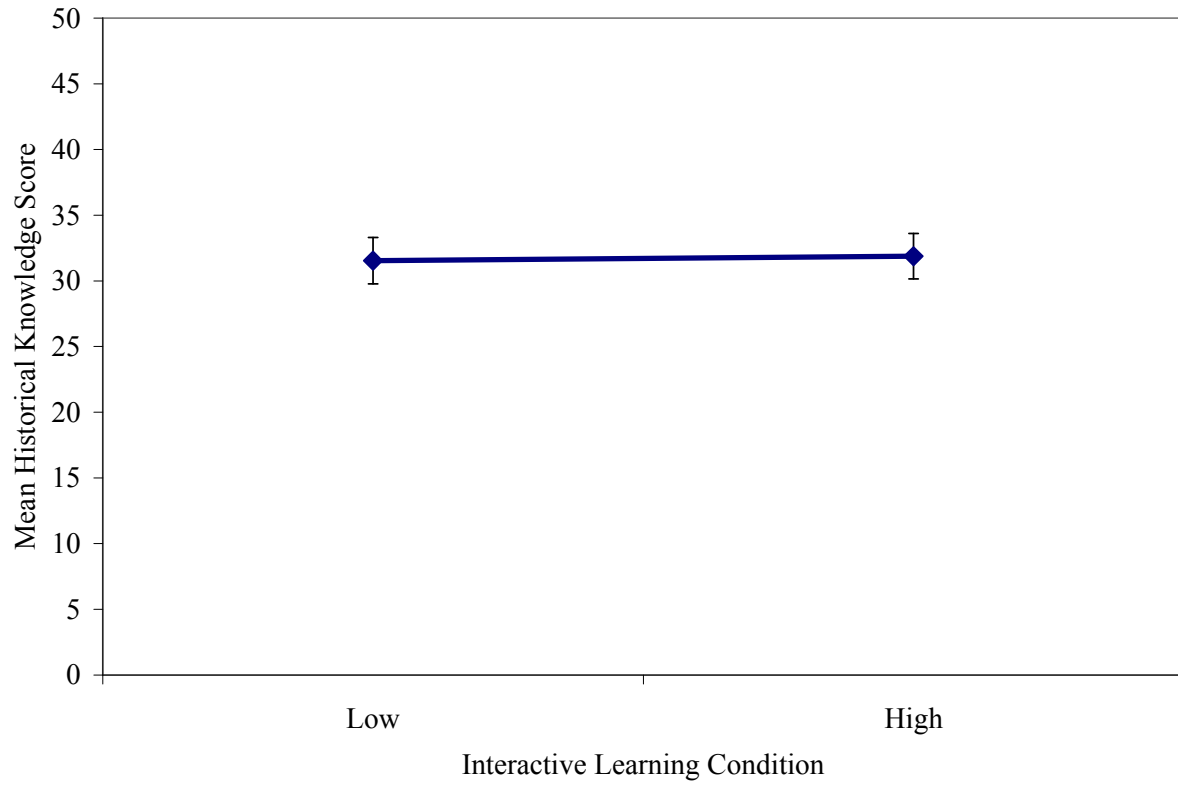
Figure 3 Mean Historical Knowledge Scores by Interactive Learning Condition
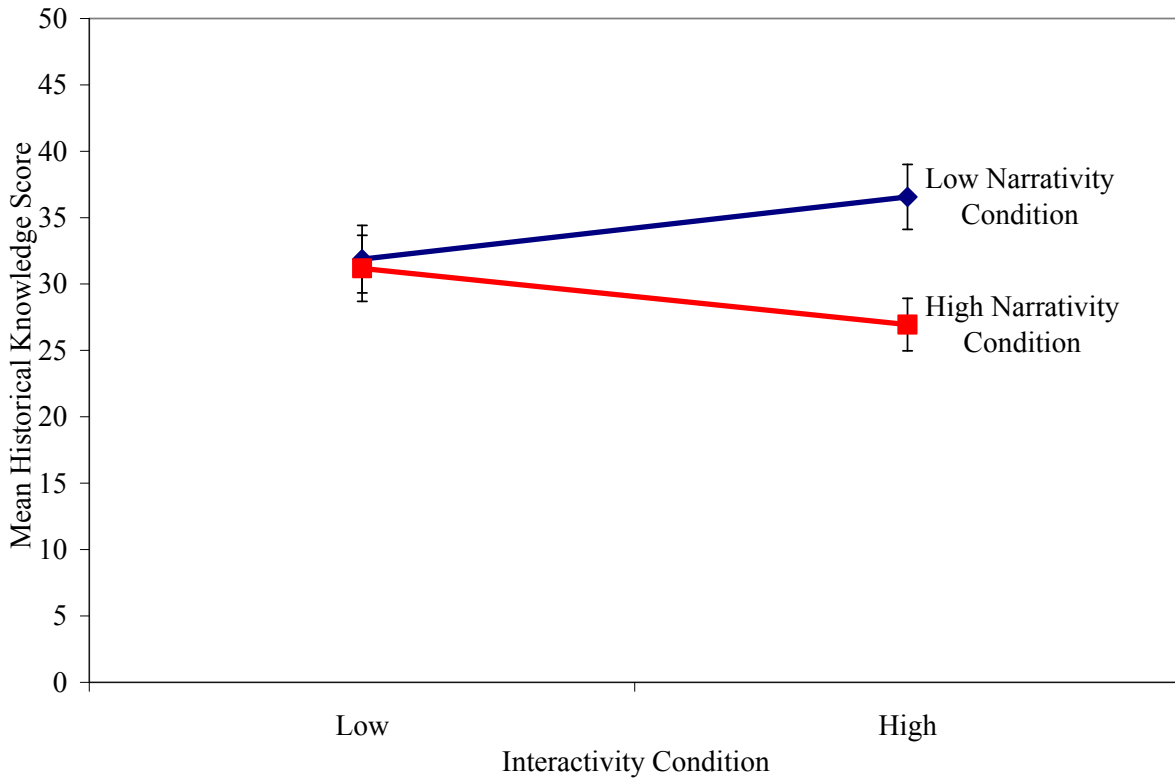
Figure 4 Mean Historical Knowledge Scores: Interactive Learning Condition by Story Learning

Condition

<h1 style="text-align:center"><u>Subjective Assessments</u></h1>

Subjective Learning Self-Assessment

In the following section I discuss the findings related to the Subjective Learning Self-Assessment. In order to test hypothesis 6, a 2 (story) x 2 (interactivity) ANCOVA was performed on participant self-assessment of learning using performance on the Guilford-Zimmerman vocabulary survey as a covariate. As seen in figure 5, the significant predicted main effect of story condition was found, $F(4,75) = 3.423$, $p = .068$ (one-tailed), such that participants in the high-narrativity conditions ($M = 2.54$, $SE = .133$) rated their learning as a result of the activity more highly than participants in the low-narrativity conditions ($M = 2.17$, $SE = .130$). As seen in figure 6, no significant main effect of interactive condition was observed, $F(4, 75) < 1$. There was also no significant interaction between story and interactivity on self assessment of learning, $F(4, 75) < 1$.

Table 2

Descriptive Statistics for Self-Assessed Learning

Story Learning Condition	Interactive Learning Condition	Mean	SD	N
Absent	Absent	2.1	0.91	20
	Present	2.24	0.70	21
	Total	2.17	0.80	41
Present	Absent	2.47	0.91	19
	Present	2.58	0.85	20
	Total	2.53	0.87	39
Total	Absent	2.28	0.92	39
	Present	2.40	0.78	41
	Total	2.34	0.85	80
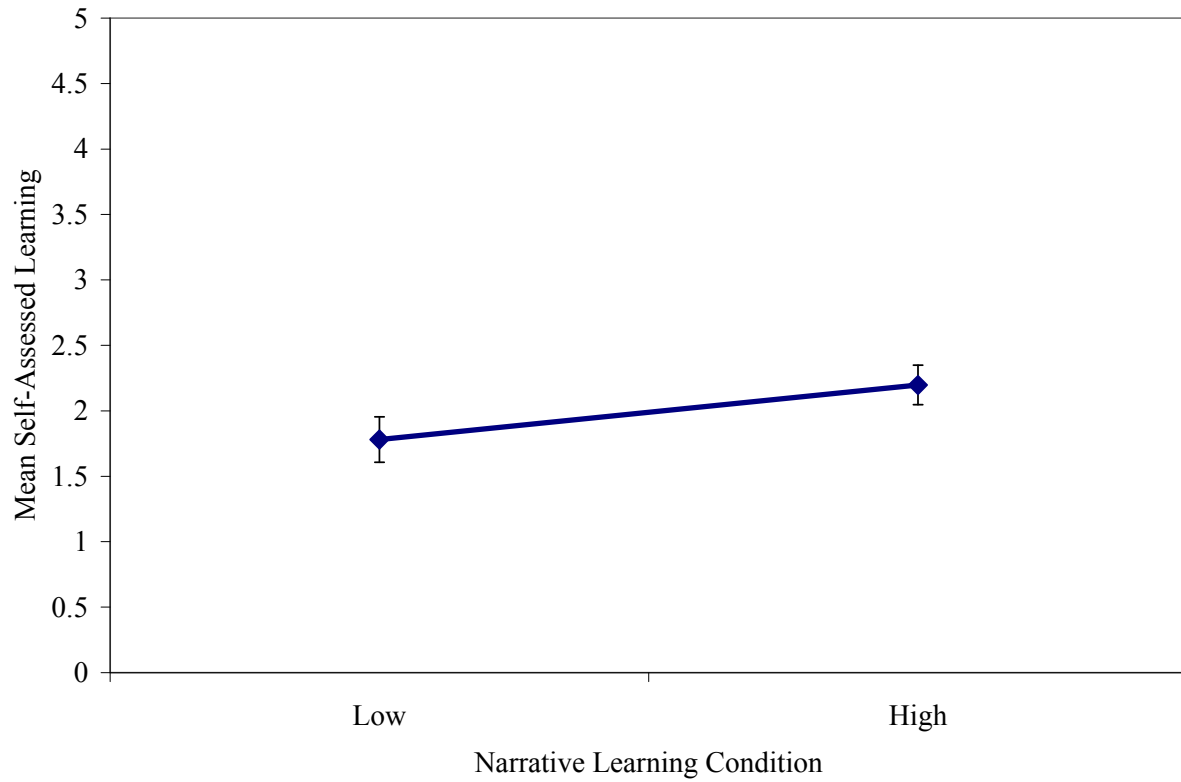
Figure 5 Mean Self-Assessed Learning Score by Story Learning Condition
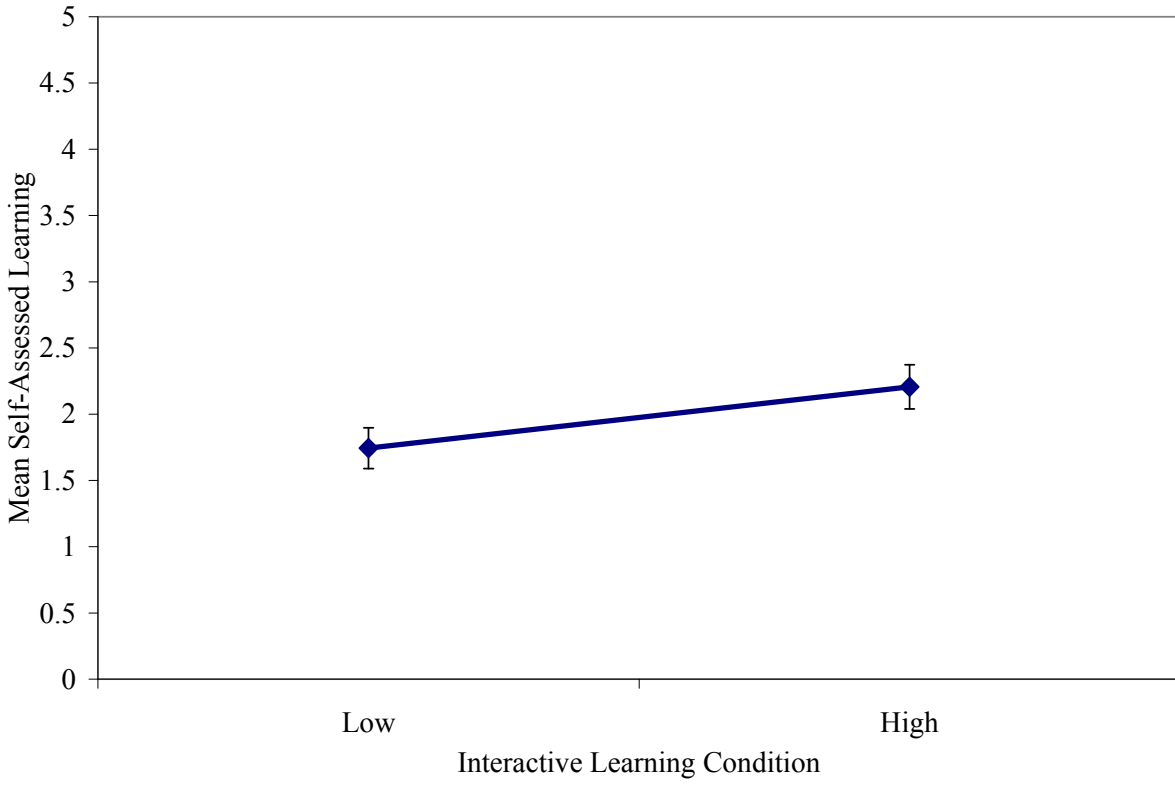
Figure 6 Mean Self-Assessed Learning Score by Interactive Learning Condition
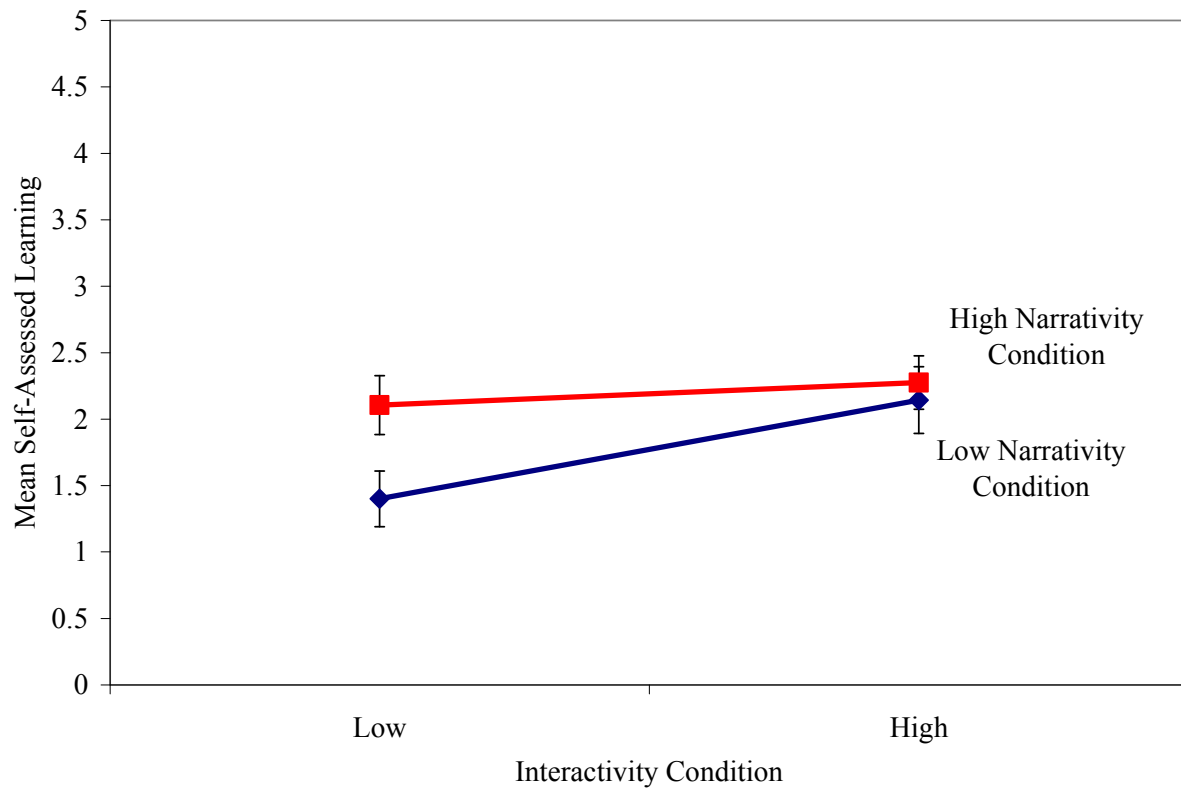
Figure 7 Mean Self-Assessed Learning Score by Story Learning Condition and Interactive

Learning Condition

Subjective Assessment of Enjoyment

In the following section I discuss findings related to the Subjective Assessment of Enjoyment. In order to test hypothesis 5, a 2 (story) x 2 (interactivity) ANCOVA was performed on participant assessment of enjoyment using performance on the Guilford-Zimmerman vocabulary survey as a covariate. A significant predicted main effect of story condition was observed, $F(1,75) = 3.354$, $p = .072$ (one tailed), such that participants who experienced the high-narrativity condition (M = 2.19, SE = .159) rated their enjoyment of the activity as higher than those who experienced the low-narrativity condition (M = 1.74, SE = .155). A significant main effect of interactivity was also observed, $F(1,75) = 4.190$, $p = .044$.

Table 3

Descriptive Statistics for Subjective Rating Enjoyment

Story Learning Condition	Interactive Learning Condition	Mean	SD	N
Absent	Absent	1.40	0.94	20
	Present	2.14	1.15	21
	Total	1.78	1.11	41
Present	Absent	2.11	0.88	19
	Present	2.28	0.99	20
	Total	2.19	0.93	39
Total	Absent	1.74	0.97	39
	Present	2.21	1.10	41
	Total	1.98	1.04	80
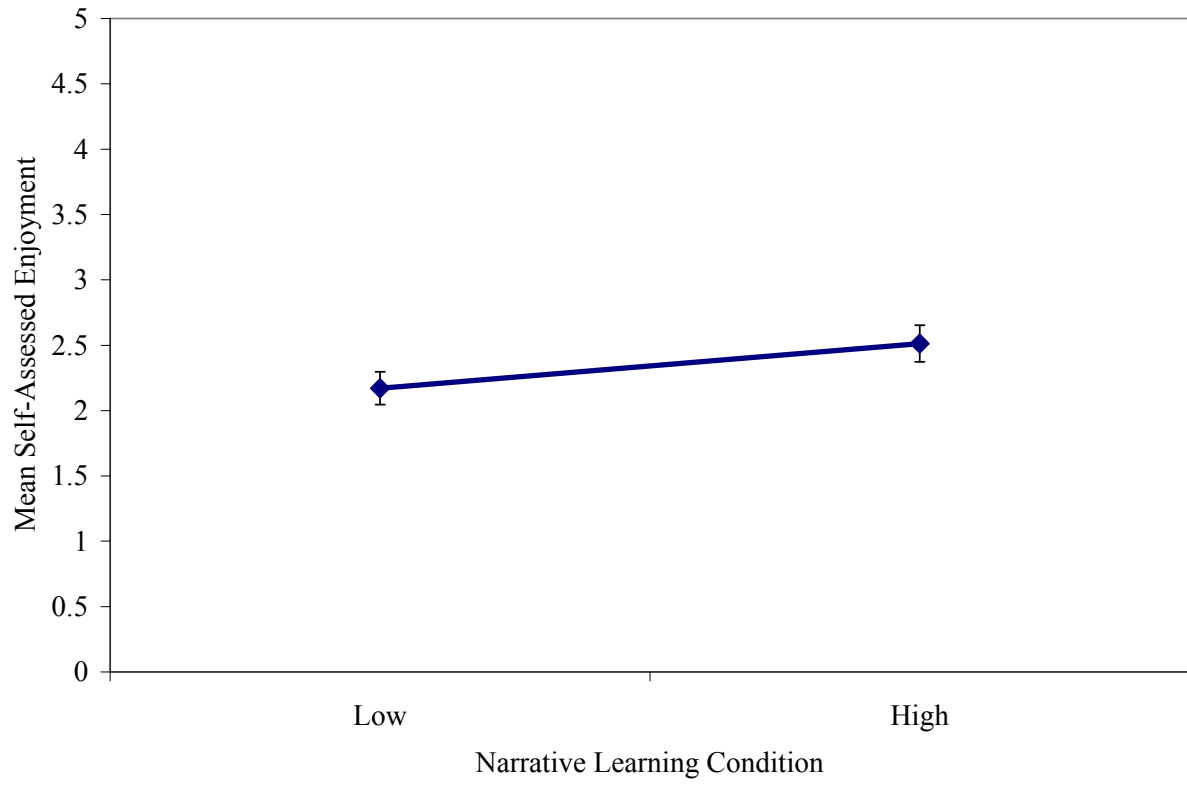
Figure 8 Self-Assessed Enjoyment by Story Learning Condition
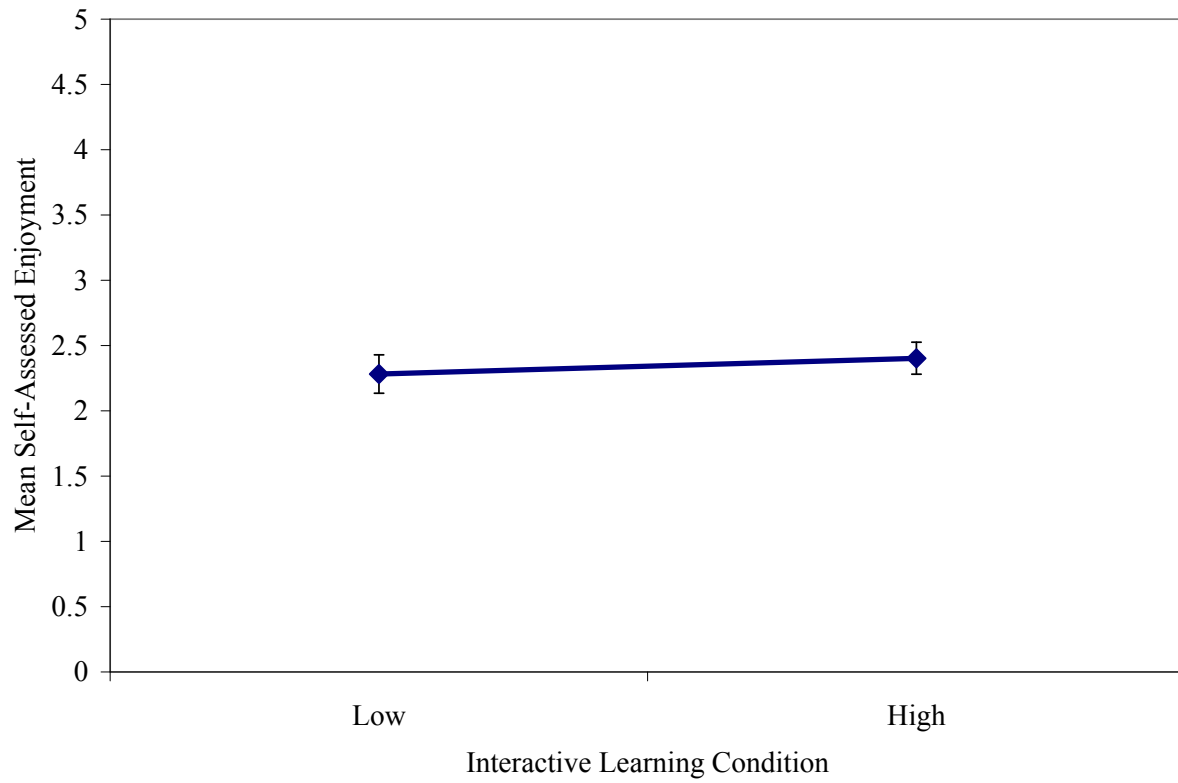
Figure 9 Self-Assessed Enjoyment by Interactive Learning Condition
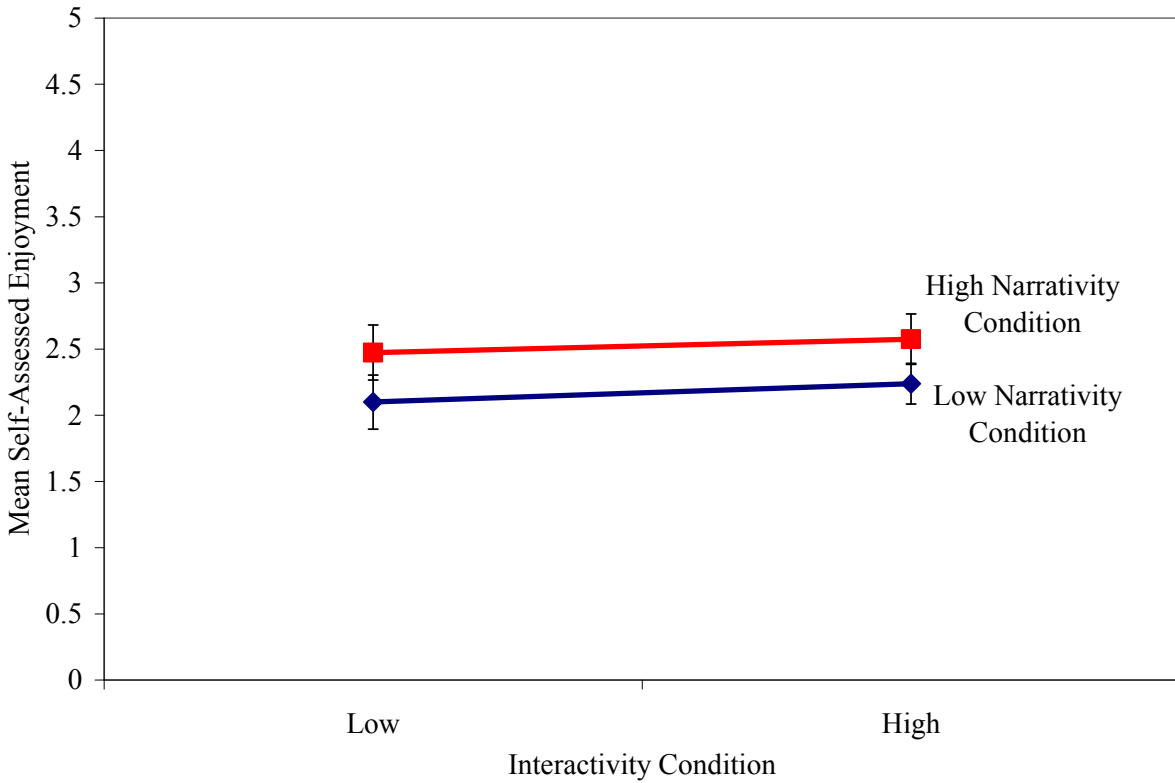
Figure 10 Self-Assessed Enjoyment by Interactive Learning Condition

Metacognitive Bias Scores

In this next section, I discuss findings related to metacognitive bias scores among participants. In order to test the hypothesis that participants in high story conditions showed lower levels of metacognitive bias (closer to zero), a 2 (story) by 2(interactivity) ANCOVA was performed on participant assessment of enjoyment using performance on the Guilford-Zimmerman vocabulary survey as a covariate. When looking at bias scores collapsed across factorial conditions, a significant positive main effect of presence of story structure in the learning condition was observed, $F(1,75) = 9.462$, $p = .003$, such that participants who were in

story-present conditions (conditions 2 and 4) generally overestimated their performance (M = .279, SD = 1.23) relative to those in story-absent conditions (M = -.554, SD = 1.06). Participants who learned in conditions without the interactive interface (M = -0.205 SD = 1.17) estimated their performance to be poorer, and were more inaccurate in doing so, than those in conditions where the interactive interface was present (M = -0.094 SD = 1.27), however the difference was non-significant, $F(1, 75) < 1$.

With regards to metacognitive bias, no significant interaction was observed between story and interactivity, $F(1,75) = 2.914$, however a comparison of cell means is instructive nonetheless. With regards to metacognitive bias per condition, participants in condition 1 (no story, no interactivity) showed a moderately negative mean metacognitive bias of M = -0.442, with SD = 1.01. Participants in condition 2 (story, but no interactivity) showed almost no metacognitive bias, at M = 0.044, with SD = 1.30. Those participants who experienced learning condition 3 (interactive format, but no story) showed the strongest negative bias of all the groups with M = -0.661, SD = 1.12. Finally, participants in condition 4 (the full SLE, with interactive format and story structure present) showed the highest metacognitive bias by far, at M = .554, with SD = 1.06.

Table 4

Descriptive Statistics for Metacognitive Bias Scores

Story Learning Condition	Interactive Learning Condition	Mean	SD	N
Absent	Absent	-0.442	1.01	20
	Present	-0.661	1.12	21
	Total	-0.554	1.06	41
Present	Absent	0.044	1.30	19
	Present	0.503	1.16	20
	Total	0.279	1.23	39
Total	Absent	-0.205	1.17	39
	Present	-0.094	1.27	41
Total	Total	-0.147	1.21	80
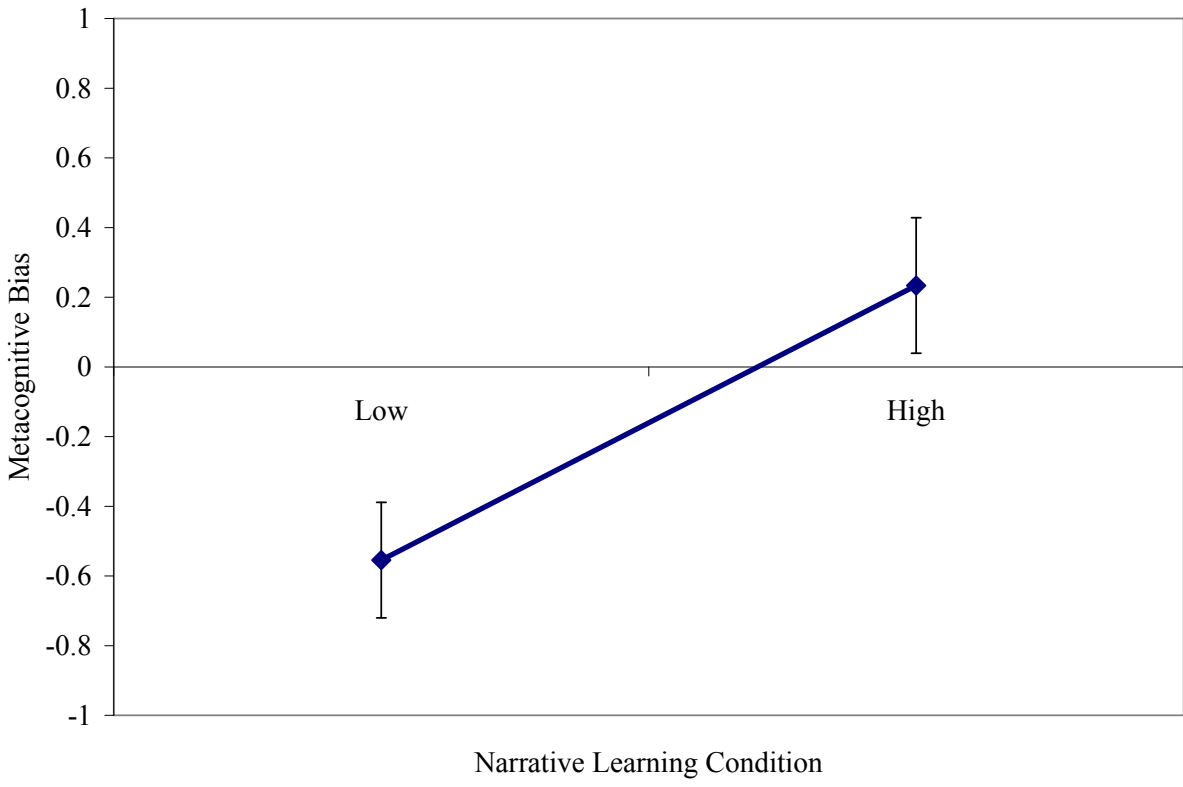
Figure 11 Metacognitive Bias by Story Learning Condition
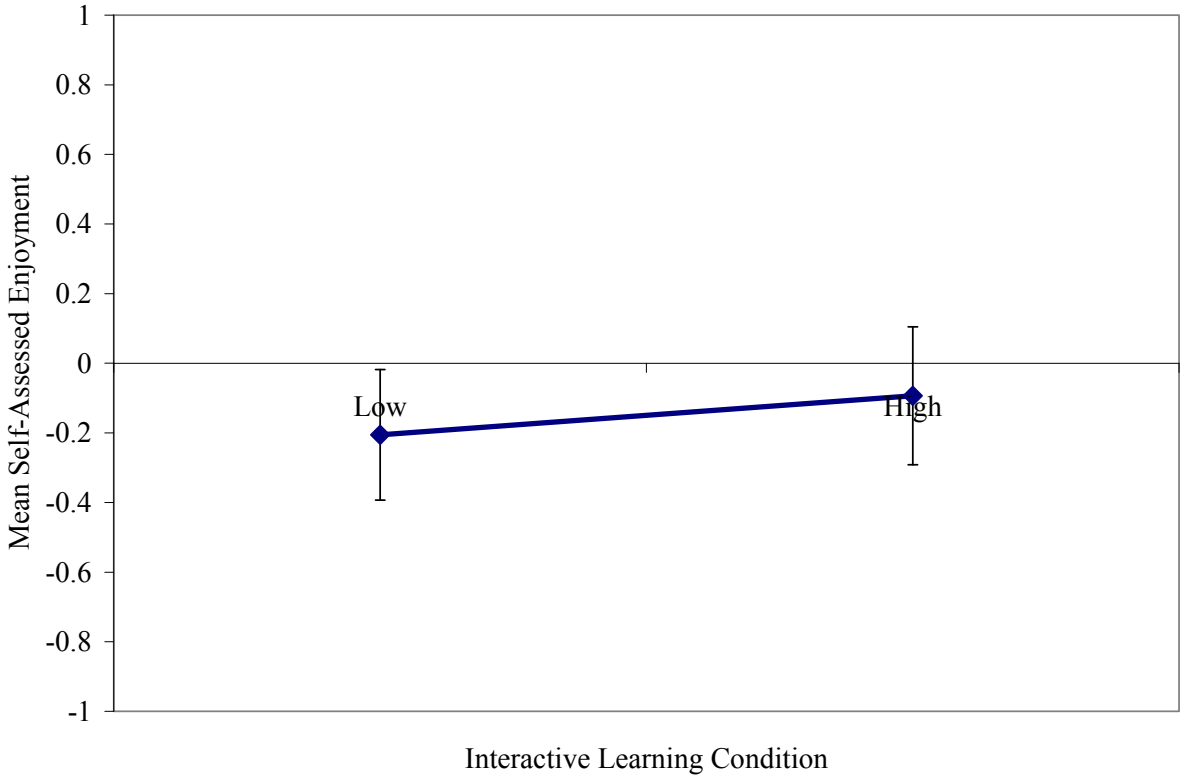
Figure 12 Metacognitive Bias by Interactive Learning Condition
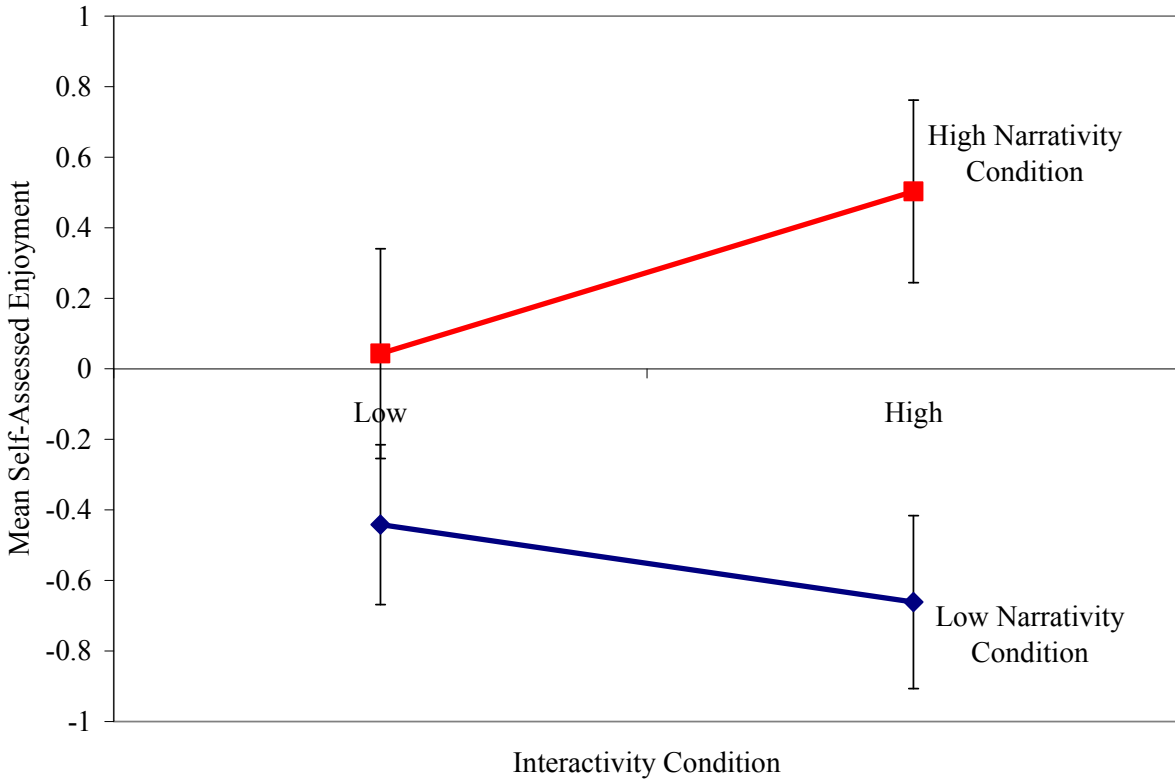
Figure 13 Metacognitive Bias by Story Learning Condition and Interactive Learning Condition

CHAPTER FIVE: CONCLUSION

Hypotheses Revisited

H1: Story Improves Retention of Learning Material

The hypothesis that the presence of story structure in a learning exercise would improve retention of learning material was not supported by our results. In fact, while a significant effect of story on learning material retention was observed, it was opposite to that predicted based on the literature. In this case, the presence of narrative structure actually resulted in weaker retention of learning material. However, this finding was not consistent across both conditions in which story was present. In condition 2, where story was present but not interactivity, the mean retention score for participants was virtually identical to that in condition 1, where neither story nor interactivity were present. However, in condition 4, where both story and interactivity were present, there was an enormous drop in retention of historical knowledge from the exercise. Since participants in condition 3, who learned material interactively but without a narrative structure, actually did about as much better than the baseline as those in condition 4 did worse, it seems that when learning using an interactive tool, participants learned and retained information much more poorly when a narrative structure was present than when it was absent. This result is difficult to resolve with the extensive support for the idea of narrative structure improving learning. This issue is discussed below at greater length.

H2: Interactivity Improves Retention for Learning Material.

This hypothesis was provisionally supported by our results. While there was no significant main effect of interactivity on retention, a quick look at Figure X clearly illustrates why. Since narrative structure seems to have so negatively impacted learning when in the presence of interactivity, the positive effect in condition 3 was drowned out by the approximately equal negative effect in condition 4. When comparing the baseline condition (condition 1) with condition 3, a clear positive trend emerges, although the results fail to reach significance.

H3: Story and Interactivity Together Produce the Best Learning Performance.

This finding was not supported by the experimental results. In fact, participants in this condition showed the lowest mean retention scores by far of any group in the experiment. Possible explanations for this are considered below, including hyperarousal, information overload, and modulating effects of interactivity, etc.

H4: No Story and No Interactivity Should Produce the Worst Learning Performance.

This hypothesis was not supported by our results. Participant mean retention scores in condition 1 were right in the middle of the pack, and almost identical to scores in condition 2.

H5: Increased Levels of Interactivity and Story will Produce Increased Levels of Subjective Enjoyment of the Experience.

This hypothesis was fully supported by the results. Significant positive effects of both interactivity, $F(1,77) = 4.994$, $p = .028$, and story, $F(1,77) = 3.993$, $p = .049$, were observed on

subjective rating of task enjoyment. This finding strongly suggests that the presence of cohesive narrative structure strongly increases a learners comfort with and confidence in a learning tool. Generally speaking, verbal feedback from participants in condition 4 was extremely positive. One point raised, however, by an individual with very extensive video game experience, was that the story was boring in comparison to the types of games he was used to. One specific suggestion that he made was that the designers should include more combat and allow the player to kill the overseer pursuing them. This raises an interesting point with regards to game format and subjective experience. As the game industry (and the mainstream media in general) continue to escalate the level of violence in entertainment, it may become increasingly necessary for the designers of these sorts of tools to move toward the established norms of the entertainment industry in this regard. However, this increase in public acceptance (and even expectation of) violence in media is not generally paralleled by the tastes of those who choose, rate and assess learning games for use in classrooms and other learning environments, whose tolerance for violent content is generally well below societal norms. Accordingly, this may represent a problem for the designers of SLEs, as they may "take fire" so to speak, from both sides. Some users may be bored by the lack of conflict in such learning tools, while educators may be repelled by even the smallest hint of violent content. Thus, this is likely to become a design consideration if such systems are introduced into classrooms on a more routine basis.

However, the majority of participants in condition 4 volunteered, without prompting, that the system was much more interesting than the methods by which they had learned social science content, and furthermore, in many cases, stated that they believed that they had learned a great deal from the exercise. Anecdotally, that confidence, both in the engaging quality of the learning

experience, and in the learning utility of the SLE, was not reflected in any of the other three conditions.

H6: Increasing Levels of Interactivity and Story will Produce Increased Levels of Belief in Participants that Learning Has Occurred.

This finding was partially supported. Participants who experienced conditions in which narrative was present reported significantly higher perceived levels of learning, $F(1,77) = 3.975$, $p = .05$. As discussed in the H5 subsection above, this finding strongly suggests not only that SLE format increases learner enjoyment of the learning task, but also that it improves learner confidence in the quality of their learning. While this result is generally a positive development for advocates of game learning, it has a potential downside. Since the results of this work suggest that individuals who learn in SLEs have greater confidence in the quality of their learning, but that confidence is not reflected in improved learning efficiency, it is possible that SLEs may lead learners to believe that they are far more competent in their knowledge of subject material than they actually are. This overconfidence could lead to the development of inaccurate metaknowledge, which is likely to result in poorer decision making under certain circumstances (deciding not to study any more for a test, for instance). The discrepancy between actual performance and belief in the quality of one's performance is commonly termed "Metacognitive bias," and is discussed at length below.

Metacognitive Bias

Although no specific predictions were made for metacognitive bias, the findings from this measure contribute significantly to an understanding of the hypotheses, and so merit a discussion in this section. As mentioned above, we observed significantly higher metacognitive bias among participants in learning conditions where story was present. Moreover, the pattern and direction of that bias was different between conditions as well. Since metacognitive bias represents an average normalized difference score between how well participants' thought they learned the material and how well the assessment suggested that they learned it, when dealing with metacognitive bias scores, positive scores indicate overconfidence (the participant thought they did better than they did) and negative scores i underconfidence (participants believe that they did not do as well as the assessment indicated they had), and a score of 0 indicates a perfect correlation between predicted and actual performance (Fiore, S. M., Cuevas, Scielzo, & Salas, 2002; Koriat & Bjork, 2005). Since participants were never given feedback on their performance on the assessment (and in fact, made their prediction of learning before they took the assessment) their estimate of performance was based only on their subjective experience while undergoing the learning condition.

As seen in Table 3, while there was a large difference in the direction in which they erred, participants in story-present conditions were actually significantly more accurate with regards to their knowledge level than were those in story-absent conditions. This suggests that narrative may help participants to assess their learning, possibly by helping them to see their knowledge as a connected whole.

Overally, these results have interesting implications for the role of story in learning, as they suggest that story, in the absence of interactive format, may improve metaknowledge regarding learning material, although the possibility cannot be discounted that significant amounts of additional learning were occurring in the story condition which were not being captured by the assessment. Even if this alternative interpretation were true, however, the vast majority of assessment procedures in current school systems follow the pattern of the assessment used here, and therefore must be viewed as the most practical rubric for assessing learning in classroom environments. Accordingly, if this test did not adequately assess some types of learned declarative knowledge, then the similar tests used in actual real-life school settings would be unable to detect it either, thus rendering the question moot in this context. Ultimately, the investigation of alternate testing procedures for use in classroom environments is well beyond the scope of this work, and must be left to future research projects.

. Although it is probably preferable to underestimate, rather than overestimate, one's knowledge of a subject, it is certainly the case that it is best to have an accurate picture of the strengths and weaknesses in one's own knowledge. Moreover, judgments of learning are generally predictive of long term retention of material (Koriat, Bjork, Sheffer, & Bar, 2004). Since recall was assessed less than half an hour following conclusion of the learning task, it is entirely possible that the initial objective assessment of performance will prove to be less indicative of long term retention than the subjective self-assessment.

Overall, however, the findings regarding the discrepancy between subjective and objective assessments of learning performance suggest that story in games may well be a two-edged sword. While participants reported higher affect in conditions with higher levels of story (and the highest affect for those in the high story and high story condition), this did not correspond well

70

with their actual recall of material. Participants in condition 4 (high story, high interactivity) reported the highest mean enjoyment of the task, and the highest mean self-assessed learning, but showed the least actual recall of learning information of all the groups. This is a clear indication of metacognitive bias (Maki, 1998) (Cuevas, Fiore, Bowers, & Salas, 2004) and is certainly worthy of note, as it suggests a serious disconnect in the ability of users to metacognitively monitor and assess their own performance (Cuevas et al, 2002). Moreover, the bias was not uniform across all participants, but varied with respect to the learning condition they had experienced.

While this type of variation in self-assessment ability has been associated with incompetence or lack of experience with a task (Kruger & Dunning, 1999), it is difficult to make the case that participants were differentially incompetent in the high story conditions relative to the low story conditions. However, it is possible that the unfamiliarity of participants with learning in the context of a story made them less able to assess their own learning, in no small part because they could not be told ahead of time what material would be assessed on the test.

Final Analysis of Results

On a more positive note for supporters of game based learning, the positive affective results of SLE use may ultimately be more important than the lower recall efficiency observed in the high story condition. The results of the present work suggest that the presence of story, regardless of level of interactivity, improves learners' attitudes toward learning and toward the learning tool, and that interactivity further improves those attitudes. Leaving aside interactivity for the moment, this has important implications for the long term efficacy of story as a learning

tool, since research has indicated that material linked to stronger emotional states is consolidated into a stronger long-term memory trace (Cahill et al., 1996; Cahill & McGaugh, 1995; McGaugh, Cahill, & Roozendaal, 1996). If emotionality leads to stronger trace in LTM, and story leads to positive affect, then a reasonable argument can be made that an examination of retention on a longer term basis, given sufficient time for all vestiges of the learning material to have faded from working memory, might reveal an increase in recall efficiency when using learning tools in which story or interactivity (or both) play a significant role. Additionally, a very reasonable case can be made that positive affect leads to greater enjoyment of the task, therefore increasing the time which a learner devotes to the task. This increase in time on task might eventually overwhelm the effect of lower efficiency in story-based learning tools.

The lack of a significant effect of interactivity on perception of learning is interesting, but not conclusive, as there was a nonsignificant trend toward the hypothesized increase. Had sample sizes been larger, or variability lower, this trend might have reached significance, but given the apparently small effect size, this is by no means a sure thing.

Potential Explanations of Anomalous Results

Originally, we had predicted a positive effect on recall efficiency for increased levels of story and interactivity, both separately and in conjunction. This was not observed. The objective data suggest that interactivity improved performance, but only when story was not present. The extremely poor performance of participants in the high-story, high-interactivity condition relative to the low-story, high-interactivity condition is difficult to explain outside of a modulating effect of interactive format on story processing, which would be a novel finding, but one unsupported

by any existing theoretical framework. Before rushing to declare a new area of research, however, we should address some more mundane explanations.

First, it is possible that some or all of our results were influenced by the arousal state of participants. Previous theoretical and empirical work has suggested that hyperarousal (excessive excitement or alertness) may degrade performance as much as hypoarousal (fatigue or sleepiness) ((Hancock, P. A. & Warm, 1989), with an optimal "sweet spot" of high performance in the middle. This explanation would posit that the increased arousal resulting from interacting with a novel interface, coupled with the arousal resulting from using a video game, was enough to push participants to an optimal level of arousal and increased their performance in the high-interactivity, low-story condition. However, when the task of reading and comprehending a complex story with accompanying dialog was added to the learning task in the high-interactivity, high-story condition, the increased state of arousal may have been enough to push the participant out of the optimal range and into a hyperaroused state that decreased their performance.

A second, related explanation of the unpredicted result hinges on the concept of information overload. Information overload is often associated with the degradation of performance observed in participants operating in a hyperaroused state. Participants engaged in very complex learning curricula and receiving large volumes of information have been known to experience decreased learning performance, possibly because the high levels of arousal interfere with encoding. Interestingly, certain types of information may be more disruptive to learning than others, particularly in children. The monitoring of both spatial information and social cues has been shown to be particularly deleterious to performance (Doherty-Sneddon, Bonner, & Bruce, 2001).The mechanism generally used to explain the decrease in performance associated with high information load is inability to identify and focus on the pertinent information because

of the high ratio of "noise," in this case irrelevant information, to "signal," or task relevant information. This analogy to signal detection theory is helpful, but fails to address another issue that could be in play here. In the present work, the experimental task was not clearly defined for participants in advance in order to avoid the creation of demand characteristics; accordingly, participants had no way of knowing which elements of the information with which they were presented were considered "learning material," and which were not. In essence, they had no idea what a "signal" or "non-signal" looked like. Accordingly, they are likely to have attended either to information that was more meaningful or interesting, or to have hypothesis-guessed and attended to the information they thought was more likely to be assessed later. Either strategy could well have lead to a pattern of encoding that emphasized the "wrong" aspects of the presented material (i.e. those elements of story and characterization that were meant to support the intended learning material). Thus, hyperarousal and information overload, together or separately, may have contributed to the unexpected finding. However, both of these conditions are generally associated with negative affective states (being overwhelmed, stressed, or overworked), and in this case, individuals interacting with both story conditions reported roughly the same (very high) affective experience. This factor alone argues strongly against an arousal or information-load based explanation for the objective finding.

Related equally to information overload, though less to hyperarousal, is the possible influence of dilution of learning material. While the addition of story and story may add context to information, it also must, by definition, add information as well. That this information is not intended to be learned by the SLE designer does not diminish the additional memory load generated by this extra information. As a result, some attentional resources were probably diverted from the learning material to the extraneous story-specific material. Thus, it is possible

that in conditions where the story was present, the dilution of the learning material with story material resulted in lower scores not because the participants failed to retain as much information on the whole, but because they failed to encode and retain as much of the information that was specifically tested for. From a cognitive standpoint the problem could be occurring at encoding, when less of the relevant information is processed, during storage, in which the trace for all material (both learning and story) degrades equally, or during recall, when less of all the material is able to be retrieved. However, the lack of a negative effect of story in the absence of high interactivity strongly argues against this explanation.

Having addressed the possible alternative explanations, let us now explore the possibility that a genuine effect of story and interactivity on performance was observed. First, the subjective data observed suggest that the presence of story, as expected, both improved participants' sense of enjoyment of the task and increased their perception of their own learning. Participants consistently reported significantly higher levels of enjoyment and self-assessed learning in high story conditions over low story conditions. This suggests that not only did participants experience a more enjoyable interaction with the learning material, but also felt a deeper connection to it as a result of the presence of story. The decrease in objectively-assessed learning needs, therefore, to be seen in the light of the clear positive effects on attitude. However, this presents a particularly insidious problem for advocates of story-based game research. If people like story-based games, and believe that they learn better when using them, but in fact do not learn as well, doesn't this suggest that story in games represents a step backwards in learning methodologies, especially when compared to the effect of game format alone? Perhaps, but one needs to take into account a number of secondary factors outside of the scope of this study, and therefore not assessed. First, people tend to engage more often in more enjoyable activities. The

75

digital game industry has invested many years, and many billions of dollars in developing ways

of inducing positive affective states in individuals using their products. Our findings suggest that

the presence of story enhances positive affect still further Accordingly, we can make a simple

"time on task" argument in favor of high-narrativity learning systems: more enjoyment equals

more interaction. Logically, more interaction should lead to more learning. Therefore, in the long

run, high narrativity game systems should lead to improved learning. This somewhat paradoxical

conclusion is boosted by the finding that participants in our study, possibly as a result of the

positive hedonic content of the task, rated their learning of the subject material as significantly

higher in the high-story conditions.

Lessons Learned

Inevitably, when conducting research one finds, upon analyzing the results, that they wish they

had made different decisions to their experimental design and data collection procedures. In this

study, a number of such changes might, in retrospect, have revealed interesting results or

explained the observed results more clearly. The most significant of these relates to our objective

assessment of learning. In this experiment, we chose to look at the comparative performance of

learners in different learning conditions, but we did not establish a true baseline for completely

untrained participants. Had we added a pretest to all participants, or set aside another group of

participants to take the assessment without experiencing any learning condition (or after having

completed a dummy condition), we would have been able to more clearly determine whether or

not learning was actually occurring in the baseline condition. As a result, the design of the

experiment allowed us to compare learning performance across conditions, thereby establishing

relative quality of learning between groups. However, it did not allow us to compare the learning performance of any of those groups against an absolute standard in order to definitively establish that learning was occurring in any of them. At the time, we were concerned that the use of a pre-test might have created priming, and rejected the idea of a fifth condition as another group would have diluted our statistical power and unacceptably increased our likelihood of Type II error. Moreover, the existing theoretical and empirical literature offered no reason to believe that our baseline condition would not be the poorest learning condition, and therefore seemed to undercut the necessity of addressing the issue.

A second decision that might have been changed was our choice to only provide a single posttest to participants. Had we brought participants back later to perform a retest, we might well have a better understanding of how learning format impacted the quality of the memory trace at increasing intervals from the training. Due to our design, we have only a single data point, collected shortly after the learning exercise, on which to base our analysis. However, it is not certain that such a course would have revealed results any different from those currently observed, and the practical difficulties of getting participants to return at a later date to take a single 15-minute test might well have been insurmountable, particularly given that the semester ended just after data collection concluded, and many of our participants would have graduated and moved on to jobs or other schools.

In retrospect, these decisions might well have improved our understanding of the observed outcome. However, during the planning phase of the study, the experimental design was considered adequate to answer the original research questions.

Future Research

As a result of our unexpected findings, a number of new research questions have been raised. First, and most importantly, what is the real relationship between interactivity and story on learning in Synthetic Learning Environments? Since we believe this to be the first experimental study ever to address this explicitly, the most obvious and pressing issue is to attempt to replicate these findings in a different environment. This work is already underway. In an attempt to assess whether these findings are replicable using another population, a similar experiment is being carried out using a population of 4th graders at a public elementary school.

Even if a replication of this study finds similar results, other important questions must be addressed. First, what is the underlying mechanism of this action? Is it an arousal or capacity based process, in which the additional mental burden of interacting with a game interface whilst attempting to read and understand a story simply overwhelms the ability of the learner to encode a solid memory trace? Does the phenomenon occur at the encoding stage at all, or is it a retention or recall problem? Could it be that the information learned in a SLE is simply stored in such a way as to make recall of information using a traditional pen and paper test difficult? Assuming that interactive format represents a true modulator variable for story-based learning, what other constructs might influence story-based learning?

One immediate step that suggests itself to any researcher intending to replicate and extend the present work is implied by the previous section on potential improvements to the experimental methodology. First, the present work can really only claim to be able to assess recall of learned information on a relatively short-term basis (minutes to an hour). In order to really determine the practical implications of this result, it will be necessary to determine whether this result holds up

over longer timeframes, such as days or even weeks. This longer timeframe represents a more operationally-valid assessment anyway, as most educational settings aim at creating and assessing the effectiveness of learning and retention across much longer time frames. A good initial replication and extension program would be to retest participants one to two weeks after the learning exercise. A similar, but related issue is the effect of multiple learning sessions on retention. Do SLE-based learning and traditional learning paradigms show similar patterns of encoding, retention, and recall across time and across multiple iterations? Finally, the present work has not completely explored the ramifications of the apparent subjective preference of learners for SLE-based learning programs. Does this finding generalize outside of the population of college students? Are there other factors at work besides story structure and interactive format that might work to modulate learner's responses to such systems? As is often the case with research studies, the present work has potentially raised more questions than it has answered. Only further research can place this initial study in context and extend the body of knowledge about SLE based learning.

APPENDIX A: LEARNING POINTS FROM THE MUNDY MOD

Learning Point	Subject Area
Indigo grown in North Florida in Antebellum period	History and Agriculture in Florida
Slaves were kept in Florida during the Antebellum period	Florida History
The Underground Railroad may have operated as far south as Florida	Florida History
Harriet Tubman was a conductor on the underground railroad	American History
Slaves commonly hid in caves and swamps or traveled through them	American History
Some slaves returned to help other slaves escape from the south	American History
Slaves were often named by their masters and commonly did not have family names	American History
In some cases, passwords and signs were used for security purposes on the railroad	American History
The Fugitive Slave Law of 1850 (FSL) required those finding slaves outside of slave states to return them to their masters.	American History
It also set harsh penalties for those caught harboring slaves	American History
Trust was rare among slaves and rarer still among escapees. Anyone could betray you.	American History
Escapees generally did not sleep more than one night in the same place	American History
Hiding or assisting slaves was dangerous. One could be prosecuted or lynched for helping runaways	American History
Uncle Tom's Cabin was a book that was influential in sparking the abolitionist movement	American History
UTC was written by Harriet Beecher Stowe	American History
Magazine serial in 1851	American History
book in 1852	American History
It was illegal for slaves to be able to read	American History
Literacy was punishable by death for slaves	American History
As a result, few free blacks could read	American History
Despite the FSL of 1850, many private citizens, and a few law enforcement officers, looked the other way or assisted runaway slaves	American History

APPENDIX B: HISTORICAL KNOWLEDGE SURVEY

Historical Knowledge Survey

Section 1:

Please write down everything you remember from the learning exercise you just participated in. You may use bullet points or paragraphs, but please take your time and write legibly. There is no time limit on this survey.

Section 2:

These questions are about African-American history during the time period before and during the American civil war. Please answer the questions as best you can.

1. Who was Harriet Tubman?
   a) The editor of an anti-slavery newspaper
   b) The author of a popular novel featuring black characters
   c) A well-known abolitionist
   d) A famous conductor on the underground railroad

2. What was the Underground Railroad?

   _____

   _____

   _____

   _____

3. What was the role of a "conductor" on the underground railroad?

   _____

   _____

   _____

   _____

4. What was the Fugitive Slave Law?
   a) A law protecting escaped slaves and their associates living in the north from their former masters.

b) A law requiring escaped slaves living in the north to be returned to their former masters.

c) A law authorizing the use of force against escaping slaves, or slaves suspected of attempting to escape

d) A state law passed in New Hampshire declaring that escaped slaves who entered the state were automatically freed, regardless of the law in their master's state of residence.

5. What year was the Fugitive Slave Law enacted?_____

6. What year was the book form of the novel "Uncle Tom's Cabin" published?_____

7. Who wrote "Uncle Tom's Cabin?"

a) Henry David Thoreau
b) Harriet Beecher Stowe
c) John Wilkes Booth
d) Fredrick Douglass

8. The "Three-fifths Compromise" did which of the following?
a) Required that an escaped slave living in the north must buy their freedom from their former master for three-fifths of their market value in order to become eligible for citizenship.
b) Required that three-fifths of eligible voters had to agree in order to change a state from a slave state to a free state.
c) Defined slaves, for purposes of tax collection and congressional representation, as three-fifths of a free person.

9. During what part of the day did most escaping slaves travel?

10. What document freed many slaves living in the south?
a) Kansas-Nebraska Act
b) Civil Rights Act
c) Fugitive Slave Law
d) Free-State Law

11. What was the name of the president who signed this
    document?_____.

12. Name as many crops grown in North Florida as you can.

_____

_____

_____

_____

13. How long did slaves typically stay hidden in one place?

_____

_____

_____

_____

Section 3:

14. Did you feel that you learned the material you were presented with in this experiment?
    a) Yes
    b) No

15. Please indicate on the scale below how well you feel you learned the material presented in the experiment.

1-----------------------2-----------------------3-----------------------4-----------------------5

Not at all   A little   Reasonably well   Quite well   Very well

16. Did you enjoy engaging in the learning task in this experiment?
    a) Yes
    b) No

17. Please indicate on the scale below how much you feel you enjoyed engaging in the learning task in this experiment.

1-----------------------2-----------------------3-----------------------4-----------------------5

Not at all   Somewhat   Reasonably enjoyable   Quite enjoyable   Very

                    enjoyable   enjoyable

APPENDIX C: BIOGRAPHICAL QUESTIONNAIRE

Assessing the Role of Story and Interactivity in Learning using a Digital Humanities Game:
Biographical Questionnaire

Thank you for participating in this study. Please answer the questions below to the best of your ability. If do not know, or you are unwilling to provide the answer to a question below, please leave it blank and notify the experimenter.

1) Age:_____.

2) Sex: M   F

3) Do you have 20/20 Vision?_____.

4) If your vision is less than 20/20, is it currently corrected to 20/20 by glasses, contacts, or other means?_____.

5) Do you have any reading-related disabilities (e.g. Dyslexia)?_____.

6) Number of hours you play video games per week_____.

7) Are you familiar with the game "Neverwinter Nights," developed by BioWare?_____.

8) How familiar would you say you are with African American history?
   Not at all   Somewhat   Very Familiar

9) How familiar would you say you are with Central Florida history?
   Not at all   Somewhat   Very Familiar

Is there any reason you would feel uncomfortable using a video game?_____

_____

_____

_____.

APPENDIX D: PARTICIPANT SIGN UP SHEET

Dr. Rudy McDaniel of UCF's Digital Media Program is recruiting participants enrolled in "Principles of Digital Media" to participate in a research study examining digital games as a method of teaching humanities content. Participants in the study will receive extra credit in "Principles of Digital Media." To sign up to participate, please print your name, phone number, and email address below and you will be contacted to schedule an appointment to participate. If you have questions, please email adams@mail.ucf.edu.

1)_____

2)_____

3)_____

4)_____

5)_____

6)_____

7)_____

8)_____

9)_____

10)_____

11)_____

12)_____

13)_____

14)_____

15)_____

16)_____

17)_____

18)_____

19)_____

20)_____

21)_____

22)_____

23)_____

24)_____

25)_____

26)_____

27)_____

28)_____

29)_____

30)_____

31)_____

32)_____

33)_____

34)_____

35)_____

36)_____

37)_____

38)_____

39)_____

40)_____

41)_____

42)_____

43)_____

44)_____

45)_____

46)_____

47)_____

48)_____

49)_____

50)_____

51)_____

52)_____

53)_____

54)_____

55)_____

56)_____

57)_____

58)_____

59)_____

60)_____

61)_____

62)_____

63)_____

64)_____

65)_____

66)_____

67)_____

68)_____

69)_____

70)_____

71)_____

72)_____

73)_____

74)_____

75)_____

76)_____

77)_____

78)_____

79)_____

80)_____

APPENDIX E: INFORMED CONSENT FORM

Assessing the Role of Story and Interactivity in Learning using a Digital Humanities Game

I HAVE BEEN INFORMED THAT:

1. The experimenter, Mr. Adams Greenwood-Ericksen, has requested my participation in a research study.

2. The purpose of the research is to investigate the effectiveness of a learning game at teaching history.

3. My participation will involve my playing a computer game or reading a text containing historical information and answering questions about it. Prior to engaging in the study I will have to fill out a survey assessing my knowledge of pre American civil war history.

4. There are no foreseeable risks or discomforts if I agree to participate in this study.

5. I must be at least 18 years of age to participate in this study.

6. The possible benefit of my participation in this research study will be improvement in my knowledge regarding slavery, abolition, and the underground railroad in the antebellum United States.

7. The results of this research study may be published, but my name or identity will not be

revealed. The researcher will do the following to maintain confidentiality of my records to the extent allowed by law. The experimenters will keep the names of subjects confidential, use numerical codes for subjects, and will secure this information in locked files. The master list of subject information will be destroyed after subject codes have been assigned. Only specifically assigned research staff will have access to the confidential information.

8. I will receive no financial compensation for my participation in this study, but I will receive extra credit in the course from which I was recruited.

9. I understand that if I am unwilling to participate in this study, I will be allowed to complete an alternative extra credit assignment at the discretion of my course instructor.

10. I understand that the study will take no more than an hour and a half to complete.

11. Any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by Adams Greenwood-Ericksen (407-XXX-XXXX) or email: adams@mail.ucf.edu.

12. If I have questions about my rights as a subject/participant in this research, or if I feel I have been placed at risk, I can contact the Institutional Review Board, University of Central Florida, Office of Research and Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL, 32826-3246 or by telephone at (407) 823-2901.

I have read the above informed consent form. I understand that I may withdraw my consent and

discontinue participation at any time without penalty or loss of benefits to which I may otherwise

be entitled. In signing this consent form, I am not waiving any legal claims, rights or remedies. A

copy of this consent form will be offered to me.

Participant Signature _____ (Date) _____

APPENDIX F: SELECTED RAW DATA

PP	cond	Story	Interact	bio01	bio02	bio03	bio04	bio05	bio06	bio07	TotVGUse	bio08	bio09	bio10	bio11	bio12	VOCABT	SUBJ01	SUBJ02 -Learning	SUBJ03	SUBJ04-Enjoyment	HISTcomp	HISUNWT	Filter2	Z_meta	Z_learn	Meta_bias
1	1	0	0	19	0	0	1	0	0	0	0	.	0	1	0	0	42	1	2	0	2	30	12	1	-0	0	-0
3	3	0	1	19	1	0	1	0	1	3	3	.	0	1	1	0	44	1	3	1	2	22	9	1	1	-1	1
4	1	0	0	24	1	0	1	0	3	3	9	.	1	0	0	0	21	1	3	1	2	27	9	1	1	-0	1
6	1	0	0	46	0	0	1	0	0	0	0	.	0	2	1	0	38	1	4	1	3	37	13	1	2	1	1
7	2	1	0	21	1	0	1	0	2	3	6	.	1	1	1	0	26	1	2	1	1	35	15	1	-0	0	-1
8	3	0	1	22	0	0	1	0	1	2	2	.	1	1	1	0	46	1	2	1	2	44	16	1	-0	1	-2
10	2	1	0	20	0	1	.	0	1	2	2	.	0	1	0	0	43	1	2	1	2	19	9	1	-0	-1	0
11	1	0	0	20	1	1	.	0	2	4	8	.	0	1	0	0	28	0	1	0	0	48	19	1	-2	1	-3
12	4	1	1	44	1	0	1	0	1	1	1	.	0	0	0	0	37	0	1	0	0	35	12	1	-2	0	-2
13	1	0	0	19	1	1	.	0	0	0	0	.	0	1	0	0	50	1	3	0	1	46	18	1	1	1	-1
14	3	0	1	23	1	1	.	0	0	0	0	.	0	1	1	0	42	1	2	1	3	27	13	1	-0	-0	-0
16	4	1	1	19	1	0	1	0	4	7	28	.	1	0	0	0	36	1	2	1	3	38	13	1	-0	1	-1
17	3	0	1	20	1	1	.	0	3	5	15	.	0	1	0	0	27	1	3	1	1	55	20	1	1	2	-1
18	3	0	1	18	1	1	.	0	1	6	6	.	0	2	1	0	31	1	2	1	2	37	15	1	-0	1	-1
19	4	1	1	21	1	0	1	0	0	3	0	.	0	0	0	0	13	1	2	1	2	11	4	1	-0	-2	1
20	1	0	0	20	1	1	.	0	0	1	0	.	0	1	1	0	16	0	0	0	0	9	5	1	-3	-2	-1
21	4	1	1	19	1	1	.	0	10	6	60	.	1	0	0	0	51	1	4	1	4	43	15	1	1	1	0
22	3	0	1	19	1	1	.	0	4	7	28	.	1	1	0	0	48	0	2	1	4	40	15	1	-0	1	-1
23	1	0	0	18	1	0	1	0	2	4	8	.	1	1	0	0	38	1	3	1	2	38	16	1	1	1	0
24	4	1	1	23	1	1	.	0	0	0	0	.	0	1	0	0	14	1	3	1	2	41	15	1	1	1	-0
25	1	0	0	22	1	1	.	.	2	1	2	.	0	1	0	0	37	1	2	1	2	42	16	1	-0	1	-1
26	1	0	0	22	1	1	0	.	20	5	100	.	0	0	0	0	37	1	2	1	1	33	11	1	-0	0	-1
28	4	1	1	18	1	1	.	0	2	3	6	.	1	1	0	0	36	1	2	0	1	19	9	1	-0	-1	0
29	2	1	0	21	0	0	1	0	0	0	0	.	0	1	1	0	24	1	2	1	2	45	17	1	-0	1	-2
30	4	1	1	20	1	1	0	0	3	5	15	.	1	1	0	0	38	1	2	1	1	25	12	1	-0	-0	0
31	4	1	1	20	1	1	0	0	0	0	0	.	0	1	0	0	6	1	3	1	3	26	9	1	1	-0	1
32	3	0	1	24	1	1	.	0	2	4	8	.	1	2	1	0	25	1	2	1	1	33	15	1	-0	0	-1
33	3	0	1	27	1	0	1	0	0	0	0	.	0	1	0	0	33	1	3	1	3	31	13	1	1	0	1
34	1	0	0	19	1	0	1	0	3	5	15	.	1	0	0	0	24	1	2	1	2	16	7	1	-0	-1	1
35	1	0	0	28	1	0	0	0	0	0	0	.	0	0	0	0	25	1	2	1	2	31	11	1	-0	0	-0
36	2	1	0	19	1	0	1	0	3	5	15	.	1	1	1	0	24	1	3	1	2	45	17	1	1	1	-0
37	1	0	0	24	1	1	.	0	4	4	16	.	1	1	1	0	29	0	1	0	0	18	8	1	-2	-1	-1
38	2	1	0	42	0	0	1	0	0	0	0	.	0	1	1	0	28	1	2	1	3	23	11	1	-0	-1	0
40	3	0	1	19	0	1	.	0	0	0	0	.	0	1	1	0	24	1	3	1	2	38	13	1	1	1	0
42	1	0	0	35	1	.	0	0	0	1	0.2	.	0	1	0	0	29	1	2	1	2	37	14	1	-0	1	-1
43	3	0	1	23	1	1	.	0	1	1	0.3	.	0	1	0	0	22	1	2	1	1	33	12	1	-0	0	-1
44	4	1	1	22	1	0	1	0	2	14	28	.	1	1	0	0	34	1	3	1	4	28	10	1	1	-0	1
45	3	0	1	19	1	1	.	0	0	0	0	.	0	1	0	0	47	1	1	0	0	20	9	1	-2	-1	-1
46	1	0	0	19	0	0	1	0	2	3	6	.	0	2	0	0	14	1	2	1	1	34	13	1	-0	0	-1
47	4	1	1	22	0	0	1	0	2	3	6	.	1	1	0	0	16	1	4	1	4	27	12	1	2	-0	2

```
48 2 1 0 20 1 0 1 0  3 7 21   . 0 1 1 0 24 1 1 0 1 20 10 1 -2 -1 -1
49 4 1 1 18 0 0 1 0  0 0  0   . 0 1 0 0 47 1 2 1 2 29 12 1 -0 -0 -0
50 4 1 1 18 0 1 . 0  2 1  2   . 0 1 0 0 42 1 2 1 2 30 12 1 -0  0 -0
51 4 1 1 18 0 0 1 0  0 0  0   . 0 1 0 0 25 1 3 1 2 21  9 1  1 -1  2
52 2 1 0 19 1 0 1 0  0 0  0   . 0 0 0 0 10 1 4 1 4 16  8 1  2 -1  3
53 2 1 0 20 0 1 . 0  1 1  1   . 0 1 1 0 20 1 2 1 1 30 13 1 -0  0 -0
55 1 0 0 22 0 0 0 0  0 0  0   . 1 1 0 0 32 1 2 1 1 23 10 1 -0 -1  0
56 2 1 0 20 1 0 1 0  4 4 16   . 0 1 0 0 10 1 2 0 1 38 17 1 -0  1 -1
57 3 0 1 23 1 1 . 0  5 5 25   . 0 1 1 0 15 1 3 1 4 30 13 1  1  0  1
58 2 1 0 27 1 1 . 0  0 0  0   . 0 1 0 0 18 1 2 1 2 27 12 1 -0 -0 -0
59 3 0 1 20 0 1 0 0  0 0  0   . 0 1 0 0 11 1 3 1 4 51 18 1  1  2 -1
60 3 0 1 20 1 0 1 0  5 7 35   . 0 1 1 0 27 1 3 1 3 39 16 1  1  1  0
61 4 1 1 20 1 0 1 0  4 7 28   . 0 1 1 0 20 0 1 1 3 22 10 1 -2 -1 -1
63 2 1 0 19 1 0 1 0  2 3  6   . 0 1 0 0 14 1 3 1 3 33 14 1  1  0  1
64 3 0 1 19 1 1 . 0  2 6 12   . 0 0 0 0  8 1 2 1 3 12  5 1 -0 -1  1
65 2 1 0 20 1 1 . 0  1 2  2   . 0 1 0 0 46 1 4 1 3 20  9 1  2 -1  3
66 2 1 0 18 1 1 0 1  2 3 3.8  . 0 1 1 0  9 1 2 1 2 14  7 1 -0 -1  1
68 4 1 1 20 1 0 1 0  3 5 15   . 0 1 1 0 27 1 3 1 2 20 10 1  1 -1  2
69 4 1 1 19 1 1 . 0  1 6  6   . 0 1 0 0 33 1 3 1 2 18  8 1  1 -1  2
70 2 1 0 19 1 1 . 1  3 7 21   . 0 1 1 0 23 1 1 1 2 27 12 1 -2 -0 -1
71 2 1 0 18 1 0 1 0  6 7 42   . 0 1 0 0 18 1 3 1 2 39 16 1  1  1  0
72 4 1 1 22 1 0 1 0  0 0  0   . 0 2 1 0 19 1 4 1 2 35 13 1  2  0  2
73 2 1 0 19 1 0 1 0  1 1  1   . 0 1 1 0 28 1 3 1 2 31 13 1  1  0  1
74 2 1 0 23 0 0 1 0  3 5 15   . 1 1 0 0 30 1 2 1 1 46 18 1 -0  1 -2
75 4 1 1 18 0 0 1 0  1 3  3   . 0 1 0 0 41 1 2 1 2 36 15 1 -0  1 -1
76 1 0 0 19 1 1 . 0  5 7 35   . 1 1 1 0 42 1 3 1 3 57 22 1  1  2 -1
77 3 0 1 22 1 0 0 0  2 2  4   . 1 0 0 0 48 1 2 1 2 40 15 1 -0  1 -1
78 1 0 0 20 1 1 . 0  2 6 12   . 1 0 0 0 21 1 3 0 0 26 10 1  1 -0  1
79 3 0 1 20 1 1 . 0  1 2  2   . 0 2 1 0 14 1 3 1 2 52 18 1  1  2 -1
80 1 0 0 21 1 0 1 0 10 7 70   . 1 0 3 1 19 1 2 1 2 28 12 1 -0 -0 -0
81 3 0 1 21 1 0 1 0  3 7 21   . 1 1 0 0 24 1 2 1 2 35 13 1 -0  0 -1
82 3 0 1 22 1 0 1 0  0 0  0   . 0 1 1 0 17 1 2 1 2 43 17 1 -0  1 -1
83 3 0 1 22 0 0 1 0  0 0  0   . 0 1 0 0 25 1 1 1 2 36 16 1 -2  0 -2
84 1 0 0 19 1 1 . .  1 5  5   . 1 0 0 0 23 1 2 0 1 33 14 1 -0  0 -1
85 2 1 0 19 1 1 . 0  4 5 20   . 1 1 1 0 20 1 4 1 3 38 14 1  2  1  1
86 1 0 0 18 0 1 . 0  0 1  0   . 0 1 0 0 19 1 1 1 1 28 12 1 -2 -0 -1
87 2 1 0 21 0 0 1 0  1 2  2   . 1 1 0 0 39 1 3 1 3 50 17 1  1  2 -1
88 3 0 1 20 1 1 . 0  2 5 10   . 0 1 0 0 30 1 1 0 0 55 20 1 -2  2 -4
90 4 1 1 19 0 1 . 0  1 3  3   . 0 0 0 0 26 1 3 1 3 25  9 1  1 -0  1
91 4 1 1 19 1 0 1 0  5 2 10   . 1 1 0 0 35 1 3 1 2 15  6 1  1 -1  2
```

APPENDIX G: FULL VERSION STORY TRANSCRIPT

Plantation:

Narrator:

It is 1856, and you are a slave on a North Florida indigo plantation owned by Jeremiah Smith. After years of abuse you have decided to make your escape to freedom in the North. You have made arrangements to meet up with another slave who is traveling on the "Underground Railroad," the network of safehouses and abolitionist agents that helps escaping slaves reach freedom.

By this date, Harriet Tubman and other conductors on the Underground Railroad have been leading escaped slaves to freedom for almost a decade. Today you will escape from the plantation where you are held in bondage and try to make contact with your fellow escapee. Together you will begin your long journey to freedom.

First, you must locate the caves in front of you. Once inside, you must locate the other escaping slave, who will help you to find a safe place to travel to. Good Luck!

Caves:

Augustus:

You see an older black man. He speaks:

You better be the <man/woman> I've been waiting for or you're in big trouble. You escaping from the Smith plantation?

I am. Who are you?

Name's Augustus. No last name, only last name I ever had was the name of my old master, may his teeth rot and fall out. I'll never use it again, so until I find a better one I'm just "Augustus." You don't look like you've been on the railroad now for very long. We've got a long road ahead of us, if you're planning on traveling with me.

Is that where we are now? In a railroad tunnel?

Are you tellin' me you ran away from that plantation without knowing anything about the railroad? You're either really brave or really stupid. The Underground Railroad isn't a place. The Railroad is an organization of people. It's made to get slaves like us out of places like this and deliver us to freedom in the North.

CONTINUE.

Railroad's the best way out of this place, and the only way a kid like you will make it out alive. Good people take care of us, give us a place to sleep during the day, give us some food and

104

sometimes a guide to the cabin of the next helpful soul; that's the railroad. Decent folks risking their lives to help us 'cause they know slavery aint right. So what's your name?

My name's <FirstName>. <FullName>.

<FirstName> eh? Well <FirstName>, we've got a long way to go so we'd better get moving. I know the way to the next "station" on the railroad, but we'd better get moving if we want to get there before it's light. If we get seperated, remember that they won't trust you unless you know the password.

They won't?

You thick <boy/girl>? Helping slaves escape is illegal. Law here catches someone harboring slaves, they might go to jail. Or they might get lynched. No they won't trust you unless you know the password. And they won't let you in unless they trust you.

Why don't you tell me the password then, just in case we get separated?

Hey, I don't trust you either. We just met, remember? You find me when you get out of the caves and we'll go together. Safer for both of us that way.

Fine, I'll meet you outside the caves.

Good luck!

Goodbye.

Swamp:

Augustus:

Hey <FirstName>. Glad to see you made it to through safely. The station is right up there on that hill. The password is "The good book." Make sure you say it just like that, you get any of it wrong and they won't let you in. The old man in there is good people. His name is Joe, make sure you talk to him while you're staying there. I'll meet you out here in the morning. Now, go on up the hill behind me and get out of the wet.

You aren't coming in?

Naw, I stayed here last night. Tonight I'm staying somewhere else. Try not to sleep two nights in one place, the law has a harder time finding you if you keep on the move.

Okay, I'll see you tomorrow.

One more thing: I left my copy of the good book in there last night. See if you can bring it with you tomorrow. Joe should know where it is.

Okay. Talk to Joe, meet you here tomorrow, bring book. Got it.

Cabin:

Joe:

Welcome friend. Glad to see another escapee make it here. Wait... I think you were followed.

There's a the trap door over there by the chest, stay out of sight until I say it's safe...

Ok.

Jacob:

Give up the slave you're hiding.

I'm not hiding any slaves.

Under the Fugitive slave law of 1850, you can be prosecuted if you don't.

I said there were no slaves here.

I'd like to come in and look, if you don't mind.

I do mind, as a matter of fact.

I can ask the law to compel you.

Then you'd better come back with the sheriff.

Joe:

Phew. That was a close call. What a thoroughly unpleasant man.

Thank you for helping me, I thought I was caught for sure.

Don't worry about it, I hate that people like that feel like they can treat people like animals. You're just as human as any of us and considerably moreso than that fellow

(continue)

Well, it should be safe if you want to spend the day here and leave after dark. Don't worry about that man's threats. The local sheriff is a friend of mine, and he'll give me that much time before he comes looking. You might not believe it, but Sheriff Wylie has considerably more sympathy for our point of view on slavery than he does for that monster of an overseer.

Augustus asked me to pick up the book he left here. Do you know what he was talking about?

Ah yes, his copy of Uncle Tom's Cabin. Surprising that he carries that around with him. Few free

blacks can read, and as you know it's illegal for slaves to know how to read. So if you can read,

don't tell anyone, you could be hung for admitting it.

Uncle Tom's Cabin? He called it the "good book," I thought he meant his

Bible.

Well, that book is precious to Augustus and it has changed many lives. It's a story by Harriet

Beecher Stowe. Stowe first wrote it for a magazine in 1851. It was so famous it was published

as a book the next year. It's a powerful story and it's part of the reason I do the work I do helping

people like you escape from bondage. That's probably why he calls it the "good book."

Swamp:

Augustus:

Hey, you ready to go?

Yes, I'm ready. Here's your book!

Good! We couldn't have left without it. That book has all of the passwords and directions we

need to make it to freedom in the north. They're all based on passages from the book.

Let's go.

THIS CONCLUDES THE EXPERIMENT. PLEASE NOTIFY THE EXPERIMENTER.

APPENDIX H: PROSE STORY TRANSCRIPT

Please do not begin until you are told to do so.

It is 1856, and you are a slave on a North Florida indigo plantation owned by Jeremiah Smith. After years of abuse you have decided to make your escape to freedom in the North. You have made arrangements to meet up with another slave who is traveling on the "Underground Railroad," the network of safehouses and abolitionist agents that helps escaping slaves reach freedom.

By this date, Harriet Tubman and other conductors on the Underground Railroad have been leading escaped slaves to freedom for almost a decade. Today you will escape from the plantation where you are held in bondage and try to make contact with your fellow escapee. Together you will begin their long journey to freedom.

Having begun your escape by entering a network of caves near the plantation, you travel deeper into the caverns and meet an older black man.

"You better be the man I've been waiting for or you're in big trouble. You escaping from the Smith plantation?"

"I am," you say. "Who are you?"

The older man replies: "Name's Augustus. No last name, only last name I ever had was the name of my old master, may his teeth rot and fall out. I'll never use it again, so until I find a better one I'm just 'Augustus.'"

Eying you, he adds: "You don't look like you've been on the railroad now for very long. We've got a long road ahead of us, if you're planning on traveling with me."

You look around and ask "Is that where we are now? In a railroad tunnel?"

Augustus looks shocked: "Are you tellin' me you ran away from that plantation without knowing anything about the railroad? You're either really brave or really stupid. The Underground Railroad isn't a place. The Railroad is an organization of people. It's made to get slaves like us out of places like this and deliver us to freedom in the North."

He goes on: "Railroad's the best way out of this place, and the only way a kid like you will make it out alive. Good people take care of us, give us a place to sleep during the day, give us some food and sometimes a guide to the cabin of the next helpful soul; that's the railroad. Decent folks risking their lives to help us 'cause they know slavery aint right. So what's your name?"

You introduce yourself. The old man smiles and repeats your name. Well," he says, "we've got a long way to go so we'd better get moving. I know the way to the next "station" on the railroad, but we'd better get moving if we want to get there before it's light. If we get separated, remember that they won't trust you unless you know the password."

"They won't?"

Augustus looks at you oddly. "You thick boy? Helping slaves escape is illegal. Law here catches someone harboring slaves, they might go to jail. Or they might get lynched. No they won't trust you unless you know the password. And they won't let you in unless they trust you."

"Why don't you tell me the password then, just in case we get separated?" you suggest.

"Hey, I don't trust you either. "We just met, remember?" Augustus points out. "You find me when you get out of the caves and we'll go together. Safer for both of us that way."

"Fine, I'll meet you outside the caves."

Augustus disappears into the darkness of the caves. After resting for a few minutes, Andrew follows. After working his way through the caves, Andrew finally exits the cave into a swamp. He quickly locates Augustus standing by a dead tree. Augustus greets him. "Hey Andrew! Glad to see you made it to through safely. The station is right up there on that hill. The password is 'the good book.' Make sure you say it just like that, you get any of it wrong and they won't let you in. The old man in there is good people. His name is Joe, make sure you talk to him while you're staying there. I'll meet you out here in the morning. Now, go on up the hill behind me and get out of the wet."

"You aren't coming in?"

"Naw," replied Augustus. "I stayed here last night. Tonight I'm staying somewhere else. Try not to sleep two nights in one place, the law has a harder time finding you if you keep on the move."

"Okay, I'll see you tomorrow."

"One more thing," added Augustus. "I left my copy of the good book in there last night. See if you can bring it with you tomorrow. Joe should know where it is."

"Okay. Talk to Joe, meet you here tomorrow, bring book. Got it."

You move up the hill to where an old cabin stands. Knocking on the door, you are asked for the password. Upon repeating the phrase Augustus has given him, the door opens and a kindly old man invites him in. He greets you as he closes the door. "Welcome friend. Glad to see another escapee make it here." At a noise outside, his body stiffens and looks worried. "Wait... I think you were followed. There's a the trap door over there by the chest, stay out of sight until I say it's safe..."

Jumping up, you race over to the trap door he indicates, wrestle it up, and drop down into the cellar. Above your head, you hear the door open, and voices in conversation. It is Jacob Bittner, the overseer of the plantation from which you are escaping!

Jacob comes straight to the point. "Give up the slave you're hiding," he says.

"I'm not hiding any slaves," Joe replies.

"Under the Fugitive slave law of 1850, you can be prosecuted if you don't."

"I said there were no slaves here."

"I'd like to come in and look, if you don't mind, says Jacob.

Joe's voice is quiet, but firm. "I do mind, as a matter of fact."

"I can ask the law to compel you."

"Then you'd better come back with the sheriff," says Joe.

You hear the sound of a door closing. A minute or two later, the trapdoor opens, and Joe helps you back up into the light of the cabin.

"I can ask the law to compel you," threatens Jacob.

"Then you'd better come back with the sheriff," says Joe.

You hear the sound of a door closing. A minute or two later, the trapdoor opens, and Joe helps you back up into the light of the cabin.

"Phew. That was a close call. What a thoroughly unpleasant man."

Gratefully, you reply, "Thank you for helping me, I thought I was caught for sure."

"Don't worry about it, I hate that people like that feel like they can treat people like animals. You're just as human as any of us and considerably moreso than that fellow," says Joe.

 "Well, it should be safe if you want to spend the day here and leave after dark. Don't worry about that man's threats. The local sheriff is a friend of mine, and he'll give me that much time before he comes looking. You might not believe it, but Sheriff Wylie has considerably more sympathy for our point of view on slavery than he does for that monster of an overseer."

Remembering your conversation with Augustus, you tell Joe "Augustus asked me to pick up the book he left here. Do you know what he was talking about?"

"Ah yes, his copy of Uncle Tom's Cabin. Surprising that he carries that around with him. Few free blacks can read, and as you know it's illegal for slaves to know how to read. So if you can read, don't tell anyone, you could be hung for admitting it."

"Uncle Tom's Cabin?" You are surprised. "He called it the 'good book,' I thought he meant his Bible."

"Well," says Joe, leaning back, "that book is precious to Augustus and it has changed many lives. It's a story by Harriet Beecher Stowe. Stowe first wrote it for a magazine in 1851. It was so famous it was published as a book the next year. It's a powerful story and it's part of the reason I do the work I do helping people like you escape from bondage. That's probably why he calls it the 'good book.'"

You sleep in a spare bed at the back of Joe's cabin throughout the day. After dark, Joe wishes you well and you set out to find Augustus at the location where you agreed to meet. You finally spot him near the large dead tree outside of the cave. He calls to you as you approach. "Hey, you ready to go?

"Yes, I'm ready," you reply. "Here's your book!"

"Good! We couldn't have left without it. That book has all of the passwords and directions we need to make it to freedom in the north. They're all based on passages from the book."

"Let's go," you say, as you and Augustus set out on the long dangerous road to freedom and safety.

THIS CONCLUDES THE EXPERIMENT. PLEASE NOTIFY THE EXPERIMENTER.

APPENDIX I: IRB APPROVAL LETTER

EXPEDITED CONTINUING REVIEW APPROVAL NOTICE

From : **UCF Institutional Review Board**
FWA00000351, Exp. 5/07/10, IRB00001138

To   : **Thomas R McDaniel and Adams Greenwood-Ericksen**

Date : **March 07, 2008**

IRB Number: SBE-07-04261

Study Title: **Assessing the Role of Story and Interactivity in Learning Using a Digital Humanities Game**

Dear Researcher,

This letter serves to notify you that the continuing review application for the above study was reviewed and approved by the IRB Chair on **3/7/2008** through the expedited review process according to 45 CFR 46 (and/or 21 CFR 50/56 if FDA-regulated).

Continuation of this study has been approved for a one-year period. The expiration date is 3/6/2009. This study was determined to be no more than minimal risk and the category for which this study qualified for expedited review is:

  7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Subjects or their representatives must receive a copy of the consent form(s).

All data must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

To continue this research beyond the expiration date, a Continuing Review Form must be submitted 2 – 4 weeks prior to the expiration date.   Use the Unanticipated Problem Report Form or the Serious Adverse Event Form (within 5 working days of event or knowledge of event) to report problems or events to the IRB. Do not make changes to the study (i.e., protocol methodology, consent form, personnel, site, etc.) before obtaining IRB approval. Changes can be submitted for IRB review using the Addendum/Modification Request Form. An Addendum/Modification Request Form **cannot** be used to extend the approval period of a study.   All forms may be completed and submitted online at https://iris.research.ucf.edu .

On behalf of Tracy Dietz, Ph.D., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 03/07/2008 10:40:35 AM EST

Joanne Muratori

IRB Coordinator

LIST OF REFERENCES

Anderson, J. R., & Schunn, C. D. (2000). Implications of the ACT-R learning theory: No magic bullets. In R. Glaser & M. Bassok (Eds.), *Advances in instructional psychology: Educational design and cognitive science* (Vol. 5, pp. 1-33). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Ausubel, D. P. (1960). The use of advance organizers in the learning and retention of meaningful verbal material. *Journal of Educational Psychology, 51*, 267-272.

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning*: Grune & Stratton.

Ausubel, D. P. (1968). *Educational psychology: a cognitive view*: Holt, Rinehart and Winston: New York.

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: A cognitive view, 2nd. ed*. New York: Holt, Rinehart and Winston.

Azevedo, R., & Bernard, R. M. (1995). A meta-analysis of the effects of feedback in computer-based instruction. *Journal of Educational Computing Research, 13*(2), 109-125.

Baddeley, A. D., & Hitch, G. J. (1974). Working Memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (Vol. 8, pp. 47-90). New York: Academic Press.

Bandura, A. (1989). Social Cognitive Theory. In R. Vasta (Ed.), *Annals of child development: Six theories of child development* (Vol. 6, pp. 1-60). Greenwich, CT: JAI Press.

Barnes, B. R., & Clawson, E. U. (1975). Do Advance Organizers Facilitate Learning? Recommendations for Further Research Based on an Analysis of 32 Studies. *Review of Educational Research, 45*(4), 637-659.

Barron, B. J. S., Schwartz, D. L., & Vye, N. J. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *Journal of the Learning Sciences, 7*(3), 271.

Bartlett, F. (1932). *Remembering: A study in experimental and social psychology*. Cambridge: Cambridge University Press.

Bower, G. H., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science 247*, 44-48.

Bradshaw, G. L., & Anderson, J. R. (1982). Elaborative encoding as an explanation of levels of processing. *J. Verb. Learn. Verb. Behav, 21*(165-74).

Bransford, J. D., Barclay, J. R., & Franks, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology, 3*(2), 193-209.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience, and school*: National Academy Press.

Bransford, J. D., & Franks, J. J. (1971). The Abstraction of Linguistic Ideas. *Cognitive Psychology, 2*, 331-350.

Bransford, J. D., Sherwood, R. D., Hasselbring, T. S., Kinzer, C. K., & Williams, S. M. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. J. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in new technology* (pp. 115-141). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brickman, P., & Campbel, D. (1971). Hedonic relativism and planning the good society. In M. Appley (Ed.), *Adaptation-level theory* (pp. 287-305). New York: Academic Press.

Bruner, J. (1991). The narrative construction of reality. *Critical Inquiry, 18*(1), 1-21.

Buckley, R. B., & Clawson, E. U. (1975). Do Advance Organizers Facilitate Learning? Recommendations for Further Research Based on an Analysis of 32 Studies. *Review of Educational Research, 45*(4), 637-659.

Bushby, P. A. (1994). Tackling the knowledge explosion without overloading the student. *Aust Vet J, 71*(11), 372-374.

Cahill, L., Haier, R. J., Fallon, J., Alkire, M. T., Tang, C., Keator, D., et al. (1996). Amygdala Activity at Encoding Correlated with Long-Term, Free Recall of Emotional Information. *Proceedings of the National Academy of Sciences of the United States of America, 93*(15), 8016-8021.

Cahill, L., & McGaugh, J. L. (1995). A novel demonstration of enhanced memory associated with emotional arousal. *Conscious Cogn, 4*(4), 410-421.

Cannon-Bowers, J. A., Burns, J. J., Salas, E., & Pruitt, J. S. (1998). Advanced technology in decision-making training. In J. A. Cannon-Bowers & E. Salas (Eds.), *Making decisions under stress: Implications for individual and team training.* (pp. 365-374). Washington, DC: APA Press.

Cannon-Bowers, J. A., Fiore, S., Jeanpierre, B. (2003). Merging Entertainment and Simulation with Learning Science: The Development of Synthetic Learning Environments: University of Central Florida.

Cantwell, R. H. (no date). Learning theory for academics: An introductory model. *Retrieved on December 10, 2003 from* http://www.newcastle.edu.au/oldsite/services/iesd/publications/eunexus/articles/teaching_guides/learning_theory/learningtheory_2.htm .

Chi, M. T. H. (2000). Self-explaining: The dual processes of generating inference and repairing mental models. In R. Glaser & M. Bassok (Eds.), *Advances in instructional psychology: Educational design and cognitive science* (Vol. 5, pp. 161-238). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Chi, M. T. H., & Bassok, M. (1989). Learning from examples via self-explanations. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser.* (pp. 251-282). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Chi, M. T. H., Slotta, J. D., & de Leeuw, N. (1994). From things to processes: A theory of conceptual change for learning science concepts. *Learning and Instruction: Special issue: Conceptual change in the physical sciences, 4*(1), 27-43.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Mahwah: Lawrence Erlbaum Associates.

Cowan, N. (2005). *Working memory capacity*. New York: Psychology Press.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671-684.

Csikszentmihalyi, M. (1975). *Beyond Boredom and Anxiety*. San Francisco, CA: Jossey-Bass.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper Perennial.

CTGV. (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19*(6), 2-10.

CTGV. (1993). Anchored instruction and situated cognition revisted. *Educational Technology Research and Development, 33*(3), 52- 70.

CTGV. (1997). The Jasper Project: Lessons in Curriculum, Instruction, Assessment, and Professional Development. Mahwah, NJ: Erlbaum.

Cuevas, H. M., Fiore, S. M., Bowers, C. A., & Salas, E. (2004). Fostering constructive cognitive and metacognitive activity in computer-based complex task training environments. *Computers in Human Behavior, 20*(2), 225-241.

Doherty-Sneddon, G., Bonner, L., & Bruce, V. (2001). Cognitive demands of face monitoring: evidence for visuospatial overload. *Mem Cognit, 29*(7), 909-919.

Donovan, M. S., Bransford, J. D., & Pellegrino, J. W. (1999). How people learn: Bridging research and practice [Electronic Version]. *National Academy Press* from http://www.nap.edu/catalog/9457.html.

Eichenbaum, H. (1997). Declarative memory: Insights from cognitive neurobiology. *Annual Review of Psychology, 48*, 547.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*, 211-245.

Eysenck, M. W., & Eysenck, M. C. (1979). Processing depth, elaboration of encoding, memory stores, and expended processing capacity. *Journal of Experimental Psychology: Human Learning & Memory, 5*(5), 472-484.

Fiore, S. (2004). *Leveraging the power of story in synthetic learning enviornments.*Unpublished manuscript, Orlando.

Fiore, S. (2007). In A. Greenwood-Ericksen (Ed.) (pp. Phone discussion on metacognitive bias). Orlando, Florida.

Fiore, S. M., Cuevas, H. M., Scielzo, S., & Salas, E. (2002). Training individuals for distributed teams: Problem solving assessment for distributed mission research. *Computers in Human Behavior, 18*(6), 729-744.

Friedl, R., Wieshammer, S., Kehrer, J., Ammon, C., Hubner, D., Lehmann, J., et al. (1996). [A case-based and multi-media computer learning program on the topic of myocardial infarct, angina pectoris and mitral valve stenosis]. *Med Klin (Munich), 91*(9), 564-569.

Gagne, R., Briggs, L., & Wager, W. (1992). *Principles of instructional design*. Fort Worth, TX: Harcourt.

Gagne, R., & Driscoll, M. (1988). *Essentials of learning for instruction*. Englewood Cliffs, NJ: Prentice-Hall.

Gagne, R. M., & Glaser, R. (1987). Foundations in learning research. In R. M. Gagne (Ed.), *Instructional technology foundations* (pp. 49-83). Hillsdale: Erlbaum.

Gallagher, J. J. (1994). Teaching and learning: New models. *Annual Review of Psychology, 45*, 171.

Gonzalez, F. M. (1997). Evidence of rote learning of science by Spanish university students [Electronic Version]. *School Science and Mathematics*. Retrieved 3/29/2007 from http://findarticles.com/p/articles/mi_qa3667/is_199712/ai_n8763524/pg_1.

Guilford, J. P., & Zimmerman, W. S. (1947). *The Guilford-Zimmerman Aptitude Survey*. Beverly Hills, CA: Sheridan.

Hancock, P. A., Pepe, A., & Murphy, L. L. (2005). Hedonomics: The power of positive and pleasurable ergonomics. *Ergonomics in Design, 13*(13), 8-14.

Hancock, P. A., & Warm, J. S. (1989). A dynamic model of stress and sustained attention. *Hum Factors, 31*(5), 519-537.

Harzem, P. (2002). Searching for a future for behaviorism: A review of The new behaviorism by John Staddon. *Behavior and Philosophy, 30*, 61-72.

Hassenzahl, M. (2003). The thing and I: Understanding the relationship betweeen user and product. In M. A. Blythe, K. Overbeeke, A. F. Monk & P. C. Wright (Eds.), *Funology: From usability to enjoyment* (pp. 31-42). London: Kluwer Academic Publishers.

Horton, D. L., & Mills, C. B. (1984). Human Learning and Memory. *Annual Review of Psychology, 35*, 361.

Ilgen, D. R., Fisher, C. D., & Taylor, M. T. (1979). Consequences of individual feedback on behavior in organizations. *Journal of Applied Psychology, 64*, 349-371.

Isen, A. M., Daubman, K. A., & Novwicki, G. P. (1987). Positive affect facilitates creative problem solving. *Medical Decision Making, 11*, 1122-1131.

Jenkins, H. (No Date). From Home[r] to the holodeck: New media and the humanities. *MIT Communications Forum*, from http://web.mit.edu/comm-forum/papers/jenkins_fh.html

Jentsch, F., & Bowers, C. (1998). Evidence for the validity of PC-based simulations in studying aircrew coordination. *International Journal of Aviation Psychology, 8*(3), 243.

Jonassen, D. H., & Grabowski, B. L. (1993). *Handbook of individual differences, learning and instruction*. Hillsdale, New Jersey: Lawrence Erlbaum & Associates.

Kahneman, D., Diener, E., & Schwarz, N. (1999). *Well-being: Foundations of Hedonic Psychology*. New York: Russell Sage Foundation Press.

King, A. (1992). Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist, 27*(1), 111-126.

Kippendorff, K. (2004). Intrinsic motivation and human-centered design. *Theoretical Issues in Ergonomic Science, 5*, 43-71.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Kolb, D. A., Boyatzis, R., & Mainemelis, C. (2000). Experiential learning theory: Previous research and new directions. In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on cognitive learning, and thinking styles*.

Komaki, J. L., Heinzmann, A. T., & Lawson, L. (1980). Effect of training and feedback: Component analysis of a behavioral safety program. *Journal of Applied Psychology, 65*, 265-270.

Koriat, A., & Bjork, R. A. (2005). Illusions of competence in monitoring one's knowledge during study. *J Exp Psychol Learn Mem Cogn, 31*(2), 187-194.

Koriat, A., Bjork, R. A., Sheffer, L., & Bar, S. K. (2004). Predicting one's own forgetting: the role of experience-based and theory-based processes. *J Exp Psychol Gen, 133*(4), 643-656.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to Inflated Self-Assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134.

Kulik, J. A., & Kulik, C.-L. C. (1988). Timing of feedback and verbal learning. *Review of Educational Research, 58*(1), 79-97.

Kwan, C. Y. (2002). Problem-based learning and teaching of medical pharmacology. *Naunyn Schmiedebergs Arch Pharmacol, 366*(1), 10-17.

Maki, R. H. (1998). Metacomprehension of text: influence of absolute confidence level on bias and accu-

racy. In D. Medin (Ed.), *The psychology of learning and motivation* (pp. 223-248). New York: Academic Press.

Martin, F. (2006). *Effects of instructional elements in computer-based instruction.* ProQuest Information & Learning.

McDaniel, T. R. (2004). *A software-based knowledge management system using narrative texts.* University of Central Florida, Orlando.

McGaugh, J. L., Cahill, L., & Roozendaal, B. (1996). Involvement of the Amygdala in Memory Storage: Interaction with Other Brain Systems. *Proceedings of the National Academy of Sciences of the United States of America, 93*(24), 13508-13514.

Moreno, R., & Mayer, R. E. (2005). Role of Guidance, Reflection, and Interactivity in an Agent-Based Multimedia Game. *Journal of Educational Psychology, 97*(1), 117-128.

Murphy, L., Stanney, K., & Hancock, P. A. (2003). The effect of affect: A hedonomic evaluation of human-computer interaction. *Proceedings of the 47th Annual Meeting of the Human Factors and Ergonomics Society, 47*, 764-768.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.

Ormrod, J. E. (1999). *Human Learning, 3rd Edition*. Columbus, OH: Merrill.

Rao, S. P., & DiCarlo, S. E. (2001). Active learning of respiratory physiology improves performance on respiratory physiology examinations. *Adv Physiol Educ, 25*(1-4), 127-133.

Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research, 66*(2), 181-221.

Ryan, R. M. (2001). Beyond myth and metaphor- The case of narrative in digital media [Electronic Version]. *The international journal of computer game research*, 1. Retrieved 7 April 2008 from http://www.gamestudies.org/0101/ryan/.

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review Psychology, 52*, 141-166.

Schacter, D. L. (1996). *Searching for Memory*. New York: Basic Books.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, Plans, Goals and Understanding: an Inquiry into Human Knowledge Structures*. Hillsdale: Erlbaum.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science, 3*(4), 207-217.

Schumaker, R., & Czerwinski, M. (1992). Mental models and the acquisition of expert knowledge. In Hoffman (Ed.), *The psychology of expertise*. New York: Springer-Verlag.

Squire, L. R., Knowlton, B., & Musen, G. (1993). The structure and organization of memory. *Annual Review of Psychology, 44*, 453.

Stein, B. S., & Bransford, J. D. (1979). Constraints on effective elaboration: Effects on precision and subject generation. *J. Verb. Learn. Verb. Behav., 18*(769-777).

Stevenson, R. J. (1981). Depth of comprehension, effective elaboration, and memory for sentences. *Memory and Cognition, 9*, 169-176.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*(1), 1.

Tyler, S. W., Hertel, P. T., & McCallum, M. C. (1979). Cognitive effort and memory. *Journal of Experimental Psychology: Human Learning & Memory, 5*(6), 607-617.

Vakil, E., Hoffman, Y., & Myzliek, D. (1998). Active Versus Passive Procedural Learning in Older and Younger Adults. *Neuropsychological Rehabilitation, 8*(1), 31-41.

van den Aardweg, E. M., & van den Aardweg, E. D. (1993). *Psychology of Education*. Pretoria: E & E Enterprises.

Vogel, J., Greenwood-Ericksen, A., Cannon-Bowers, J., & Bowers, C. B. (2006). Using virtual reality with and without gaming attributes for academic achievement. *Journal of Research on Technology in Education.*

Vogel, J., Vogel, D., Cannon-Bowers, J., Bowers, C. B., Muse, K., & Wright, K. (2006). Computer and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research.*

Vye, N. J., Schwartz, D. L., Bransford, J. D., Barron, B. J., Zech, L., & CTGV (Eds.). (1998). *SMART environments that support monitoring, reflection, and revision.* . Mahwah, NJ: Erlbaum.

Wensveen, S., & Overbeeke, K. (2003). Fun with your alarm clock: Designing for engaging experiences through emotionally rich interaction. In M.A.Blythe, K. Overbeeke, A. F. Monk & P. C. Wright (Eds.), *Funology: From usability to enjoyment* (pp. 275-282). London: Kluwer Academic Publishers.

Wilson, P. N., Foreman, N., Gillett, R., & Stanton, D. (1997). Active versus passive processing of spatial information in a computer-simulated environment. *Ecological Psychology, 9*(3), 207.