Walden University

College of Education

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Antonio Thomas

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Walden University
2014

Abstract

The Effect of Textbook Format on Mental Effort and Time on Task

by

Antonio Lamar Thomas

MA, Arizona State University, 2003

BS, Arizona State University, 2001

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

The relatively little amount of time that some college students spend reading their textbooks outside of lectures presents a significant threat to their academic success. One possible solution to this problem is the use of digital games as an alternative to outside-of-class textbook reading, but a review of previous research did not reveal much information on their efficacy when compared to traditional textbooks. Using Astin's theory of student engagement as a framework, the purpose of this quantitative causal-comparative study was to determine whether a significant difference in engagement, as indicated by mental effort and time on task, existed for college students who used a digital game-based textbook versus students who used a traditional print-based textbook. The 54 undergraduate college students in this convenience sample were randomly assigned to one of the two textbook types and completed an activity session at an individual workstation. Time on task was measured with a stopwatch and mental effort with the Mental Effort Scale. The results showed a statistically significant difference in engagement between participants in the digital game-based and traditional print-based textbook groups, Hotelling's $T^2(2, 52) = 25.11$, $p < .001$, $D^2=1.86$. In the post hoc analyses, the digital game-based group had significantly higher time on task scores than the traditional print-based textbook group ($t = 34.61$, $p < .001$). The mental effort difference was not significant, although the mean mental effort score was higher for the digital game-based group. These results provide evidence of a digital game-based textbook's utility, and may inform college educators in their efforts to support a more diverse group of learners.

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Chapter 1: Introduction to the Study

Introduction

College faculty members have long recognized that the learning process starts inside the classroom, but a meaningful amount of education also occurs outside of the classroom (Handelsman, Briggs, Sullivan, & Towler, 2005; Seimens, 2005; Wegner, 2009). Lectures, class discussions, and other in-class activities are vital, but often not enough to produce successful mastery of college course material for most students (Laitinen, 2012; Seimens, 2005). For this reason, federal and state governments, higher education accrediting bodies, and administrators have required faculty to design college courses in such a way that students must spend additional time with the course content outside the lecture (Higher Education & Opportunity Act [HEOA], 2008; Laitinen, 2012; National Archives & Records Administration [NARA], 2010). Textbooks are an integral part of this process (Ryan, 2006), and this study addressed the impact that technology may have on their continued use.

Although a number of students appear unwilling to engage the college textbook outside of the course lecture (Arum & Roska, 2011; Culver & Morse, 2012; Yonker & Cummins-Sebree, 2009), research indicates that some college students are very willing to engage in playing videogames outside of the classroom (Alsagoff, 2005; Moshirnia, 2007). In fact, researchers found that college students can spend as many as 10,000 hours playing video/computer games by the time they graduate (Pivec, 2009; Prensky, 2003; Riegle, 2005). If researchers can identify a digital game format for textbook content that is compelling to students and that simultaneously creates effective learning, then educators would have a viable learning tool that may increase student engagement with learning resources outside of the classroom. The differences in these two learning formats, as they related to student engagement, were the focus of this study.

Effective video and computer games incorporate many, if not all, of the same learning principles that are used in the classroom (Gee, 2005). Good digital games get people to learn and enjoy learning through long, complex, and difficult games. Gee asserted that there are three major categories of the function of good digital games: empowering learners, problem solving, and understanding. Prensky (2001) noted that digital games that effectively engage students have six key characteristics (see Appendix A) that determine how digital games are organized and how game participation occurs.

In the educational environment, digital games, as a learning tool, have gained very little headway, however. Although many educators do agree that learning should be interesting and fun, they are very apprehensive about including digital games as a part of the course curriculum (Gros, 2007), because there is a misconception that games cannot be used for learning (Hirumi, Appleman, Rieber, & Van Eck, 2010). At the same time, many education institutions around the nation are realizing that a number of students are not performing well on the variety of assessments designed to evaluate students' mastery of curriculum content and/or student progress (Arum & Roska, 2011). What appears to be missing is research on whether the game-based approach truly engages leaners in the process; information that might compel faculty to reconsider it as an option.

In his student involvement theory, Astin (1985, 1999) discussed the critical role that engagement has in student failure or success in college (DeAngelo, Franke, Hurtado, Pryor, & Tran, 2011; Sharkness & DeAngelo, 2011). While studies have been conducted on educational games and their relation to student learning (Adams, Mayer, MacNamara, Koenig, & Wainess (2012); Alsagoff, 2005; Baek & Heo, 2010; Kiili, 2005, Pivec, 2009), no study was identified that looked at digital game-based learning theory and its relation to student learning of college course content. Because learning college course material outside of the classroom is a requirement for success in many face-to-face college courses (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006), research that focuses on the identification of a digital computer game that successfully engages students outside of the classroom and results in effective student learning is important for college students, college educators, college administrators, employers, and the community at large.

Problem Statement

College faculty greatly value textbook reading and many professors assign textbook reading on a weekly basis (Ryan, 2006). One threat to students' academic success is the relatively little amount of time students typically spend reading their textbooks outside of lecture (Arum & Roska, 2011; Culver & Morse, 2012; Yonker & Cummins-Sebree, 2009). It appears that the format of the traditional print-based textbook is not as compelling as it needs to be for students to divert some of the time spent on non-academic activities to time spent reading their textbook outside of class. Students spend many hours engaged in non-academic activities each week (Arum & Roska, 2011; Astin, 1999, 1985), but educators need to find a way to increase student time spent on engagement with the college textbook outside of lecture. What is not clear is whether an alternative format that is more attuned to current students can increase engagement.

Digital gaming is an aspect of educational technology that warrants increased attention and research. College students and other adults invest significant time in playing compelling and increasingly popular digital games (Johnson et al., 2013;

Johnson, Adams, & Cummins, 2012). Students engage in digital gameplay at four times the rate of their engagement in studying (Pivec, 2009; Prensky, 2001; Riegle, 2005). Researchers found that college students spent approximately 10,000 hours engaged in various forms of digital games, compared to approximately 2,500 hours engaged in studying outside-of-lecture (Pivec, 2009; Prensky, 2001; Riegle, 2005). These data suggest that digital games may be useful as an instructional tool for outside-of-lecture study for college students. Because of the compelling and increasingly popular use of digital games by college students and other adults,

A review of the peer-reviewed literature on college student engagement revealed several gaps in the literature. First, there was a lack of research that focused on increasing college student engagement with the college course textbook outside of lecture (Arum & Roska, 2011; Yonker & Cummins-Sebree, 2009). The review of literature did not yield any study that identified or tested the efficacy of a digital game-based textbook for increasing student engagement with the textbook outside of lecture. Second, studies that focused on game-based learning with college students looked at digital games inside the classroom during lecture, rather than outside of lecture (Johnson et al., 2013; Pivec, 2009; Prensky, 2001; Riegle, 2005). Another gap in the literature is the dearth of studies that focus on digital game use with college students. The review of literature revealed that the majority of studies that focused on digital games have been conducted with students in PK-12 (pre-kindergarten through 12th grade), rather than college students. The problem is that many college students do not exert enough mental effort or time on task with the textbook outside of lecture, and there is a lack of knowledge on the efficacy of using digital games as an alternative to textbooks related to mental effort and time on task.

Purpose Statement

The purpose of this study was to test the efficacy of a digital game-based textbook designed specifically to increase student engagement outside of the classroom above the engagement level found with a traditional textbook. This causal comparative research study examined whether a digital game-based textbook is more effective in engaging students, as indicated by mental effort and time on task, than a traditional print-based textbook. The independent variable was defined as the type of textbook (digital game-based or traditional print-based textbook). The first dependent variable was mental effort, which was measured using the Mental Effort Scale. Mental effort, also known as psychological intensity, is defined as the amount of cognitive energy that a student invests while involved with an object (Astin, 1985, 1999). The second dependent variable was time on task. Time on task, also known as physiological intensity, is defined as the amount time a student invests when involved with an object (Astin, 1985, 1999). Time on task was measured using the Learning Resources Stopwatch measure.

Research Question and Hypotheses

Research Question

The problem is that students do not exert enough mental effort or time on task with the college textbook outside of lecture, but the ability of digital game-based texts to increase engagement is not known. The research question for this study was: For a sample of undergraduate college students, are there significant differences in engagement as indicated by mental effort and time on task, based on the format of a textbook (traditional or digital game-based)?

Hypotheses

This study used two hypotheses:

Null Hypothesis (H_0): There will be no significant differences in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based).

Alternative Hypothesis (H_1): There will be a significant difference in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based), with students using the digital game-based textbook having demonstrated significantly more mental effort and time on task.

Theoretical Framework

Astin's student involvement theory (Astin, 1985, 1999) provided the theoretical framework used to understand the relation between the variables in this study. Astin's student involvement theory provides the framework for getting students to increase their engagement with the college course textbook outside of lecture. Astin (1985) argued that educators need to create content that will increase student involvement with course material. Students arrive to a college classroom with a pre-existing set of behaviors, and for some of these students that pre-existing set of behaviors includes engaging in video game play outside of the classroom on a regular basis (Pivec, 2009). Educators should recognize and capitalize on these pre-existing behaviors. Because the preexisting behavior of regular video game play for many students exists, and students need to be met where they are, a digital game-based textbook may be a viable solution for increasing student engagement with the textbook outside of lecture.

Student involvement theory posits that student engagement is characterized by time on task and mental effort (Astin, 1999). To increase student engagement, educators must find a way to increase student time on task with the textbook outside of the lecture, as well as the mental effort that students give to reading course material in the textbook outside of the lecture. Because many students give a significant amount of time on task and mental effort to playing digital games each week (Przybylski, Rigby, & Ryan, 2010), a digital game-based textbook may be a fitting instructional tool for these students.

Astin (1985, 1999) also argued that student involvement in learning is critical for student success. Astin's student involvement theory has traditionally been used to address student engagement in the college environment (Stratton, 2011). According to Astin's student involvement theory, when students engage in continuous time on task with an object, (physiological intensity) and increased mental effort (psychological intensity) involvement with an object, a student's performance, as it relates to the object, will improve. However, as research has demonstrated (Stratton, 2011), many students are not engaging sufficiently, and in some cases not engaging at all, with their primary learning resource, the college textbook, outside of the classroom. Many students are disinterested in reading their college textbooks outside of class, despite the fact that the college textbook is typically the main learning resource that students are expected to use outside of the classroom (Lord, 2008).

The second theoretical framework that was used to examine the educational digital game-based instructional tool used is digital game-based learning theory. Astin

(1985) noted that an object may be (a) highly generalized (e.g., student experience) or (b) highly specific (e.g., preparing for a chemistry exam). Digital game-based learning theory has emerged as the result of the contributions of several scholars focused on this area (Dziorny, 2005), and in particular Prensky (2001). Digital game-based learning theory has been used to develop learning centered approaches that focus on learning via digital games. These digital games have been developed to engage students. Digital game-based learning theory provides a useful theoretical framework for research on the use of digital games, student engagement, and student learning.

Nature of the Study

This study used a quantitative, causal-comparative design to determine whether significant differences in mental effort and time on task exist for students who used a digital game-based textbook and students who used a traditional print-based textbook. The sample was comprised of matriculated undergraduate college students, who were randomly assigned to one of the categories of the independent variable of textbook type. The dependent variables that were examined are mental effort and time on task, the two aspects that comprise engagement in Astin's theory (Astin, 1985; 1999). Mental effort wase measured using the Mental Effort Scale (Paas, 1992) and time on task was measured using the Learning Resources Stopwatch measure. The inferential test that was used to answer this study's research questions is Hotelling's T^2 test (Wiesner, 2006).

Definition of Key Terms

Digital game. Any game that is played on a digital device. This includes games played on the Internet; computers; gaming consoles such as the Xbox 360, Play Station, Wii, etc.; and mobile devices such as cell phones and other handheld electronics (Binark & Sutcu as cited in Yengin & Sutcu, 2011).

Digital game-based learning. Any learning that occurs as a result of combining educational content with a digital game (Prensky, 2001).

Environment. The context within which a game occurs (Rice, 2007).

Interactivity. What happens when there is extensive user interaction that possibly involves speech and interactions as well as using a keyboard to input, but typically involves reading, clicking on key icons, maneuvering a mouse adroitly, and controlling virtual objects (Rice, 2007). Interactivity causes the user to learn new knowledge in an active manner and to synthesize existing knowledge as a result of stimulating mental process. (Gee as cited in Rice, 2007).

Learning. A measurable increase in knowledge in one or more content areas.

Mental effort. The amount of cognitive effort a student gives towards engaging with an object, task, or situation (Astin, 1985, 1999). Mental effort is also known as psychological intensity.

Textbook. A major or minor source of background information that helps to aid and guide the students' understanding of the subject matter being presented by a college faculty member, regardless of the source's format. Sources may be printed, audio, digital, etc. (State Education Policy Center, 2013).

Time on task. The amount of time a student will exert towards any particular object, task, or situation (Astin, 1985, 1999). Time on task is also known as physiological intensity.

Assumptions

One assumption of this study was that participants have the cognitive ability to understand the material presented in the textbooks. Because the participants were currently enrolled college students, this assumption seemed safe to make. Another assumption of this study was that participants would answer questions on the dependent variable measures honestly. Although their willingness to do so was in question in this study, I assumed that participants had the ability to read and comprehend a college-level textbook because they were college students. The final assumption was that all participants had the intellectual and physical capacity to engage in the educational digital game used in this study. Digital media has arguably become ubiquitous in the lives of college-age adults (Zickuhr & Smith, 2012).

Scope, Delimitations, and Limitations

1. The aspect of the research problem that this study addressed is whether a digital game-based textbook is effective for increasing college student engagement with the textbook outside of lecture.

2. The scope to this study was limited to the conceptual frameworks of mental effort and time on task, the key concepts discussed in the first three premises of Astin's student involvement theory. This focus was chosen, because these conceptual frameworks are relevant to the research question and may be operationalized using valid and reliable measures.

3. To avoid introducing members of a protected group in this study, the participants were be limited to adults ages 18 and older. This strategy did not

compromise the validity of the results, as the vast majority of college students are adults.

4. A convenience sample was used in this study. Because a convenience sample is a non-probability sampling design, scientific inferences about what exists in the population of interest cannot be made. This shortcoming is largely unavoidable, due to the nature of the study, and is addressed in the limitations in Chapter 5.

5. Randomization using random assignment without replacement was used to maximize the internal validity of this study.

6. Because a self-report measure of mental effort was used, it cannot be determined whether or not research participants honestly reported their mental effort. The nature of the measures does not suggest a need of the participants to lie or give socially desirable responses, however.

7. A single textbook chapter was used that focuses on one subject, which means that scientific inferences about the efficacy of the digital game-based textbook with other subjects areas were outside of the scope of this study.

8. This study was limited to participants in the Washington metropolitan area (DC, MD, VA) of the United States. Although some regional variance might be expected in the college student population, these attributes did not seem relevant to this study. Hence, the results can be generalized with caution.

Significance of the Study

The ready access to a higher education has had a profound impact on the quality of people's live in the United States (Winters, 2012). It is likely that no institution in the United States has had more impact on the quality of people's lives than higher education

(Baum & Ma, 2007). By adding knowledge about the efficacy of alternatives to textbooks for out-of-class studying, this research aimed to improve the academic experience of college students seeking higher education and thus improve society. The social change implications of this study include providing college educators with research that may lead to a viable alternative textbook format to the traditional print based-textbook format. The alternative textbook format may increase student involvement with the course material, learning of college course material, and ultimately the academic performance of students in college courses.

A second important social change implication was determining whether an educational technology instructional tool effectively engaged students in college course content outside of the structured environment of the college classroom, which is knowledge that can lead to social change. The identification of an educational technology instructional tool that might provide an alternative to traditional textbooks would be useful. The development of an instructional tool that can successfully compete with the compelling demands that many college students face outside of the classroom (Babcock & Marks, 2011) is a difficult challenge for textbook publishers that has not been successfully met. A final social change implication is that this research study may lay the ground work for future research on increasing college students' engagement with academic course material outside of the classroom.

Summary

Astin's student involvement theory has traditionally been used to address student engagement in the college environment and says that, when students engage in continuous physical and psychological involvement with an object, student's performance as it relates to the object will improve. Gee (2005) argued that good video and computer games incorporate many, if not all, of the same learning principles that are used in the classroom. Further, good digital games get people to learn and enjoy learning through long, complex, and difficult games (Gee, 2005). As applied to this study, Digital game-based learning theory has been used to identify an engaging digital game that presents college textbook content, and this study focused on testing college textbook content in a digitally game-based format.

Textbooks are an integral part of student learning in college courses (Ryan, 2006), and ultimately college success. College professors value textbook reading and assign textbook reading regularly (Ryan, 2006). However, many college students are not engaging with their primary learning resource, the college textbook, outside of the classroom (Lord, 2008). Many students are disinterested in reading their college textbooks outside of class, despite the fact that the college textbook is typically the main learning resource that students are expected to engage in outside of the classroom in between class sessions (Yonkers & Cummins-Sebree, 2009).

This quantitative study used a causal-comparative design and determined whether a significant difference in mental effort and time on task exists for students who used a digital game-based textbook and students who used a traditional print-based textbook. This study has important social change implications, which include potentially identifying a digital game-based textbook format that can successfully compete with the compelling demands that many college students face outside of the classroom (Babcock & Marks, 2011). In the next chapter, a review of the literature used to inform this study is presented.

Chapter 2: Literature Review

Organization of the Chapter

The purpose of this quantitative study is to determine whether significant differences in mental effort and time on task exist for students who use a digital game-based textbook and students who use a traditional print-based textbook. The review of literature in this chapter focuses on college students and engagement with the course content during non-lectures and lab times. This chapter consists of the following sections: (a) Description of the Literature Review, (b) The Textbook as a Learning Object, (c) Astin's Student Involvement Theory, (d) Game-based Learning, (e) Digital Game-based Learning, (f) Rationale for Digital Game-based Textbook, and (g) Summary of the Chapter.

Description of Literature Search

The literature review conducted for this research was accomplished by searching the electronic databases of colleges, universities, and local public libraries. The search terms used in this literature review were student engagement, student involvement, time on task, mental effort, game-based learning, digital game-based learning, textbooks, and studying. I accessed databases using computer labs at a number of colleges, universities, and public libraries in my local metro area. Those institutions included University of Maryland (system), Howard University, Montgomery College, Library of Congress, and Walden University. Many of the electronic databases at these institutions used the EBSCOhost search engine that searched the following databases: Educational Resource Information Center (ERIC), Education Research Complete, SAGE, and ProQuest Central. When searching at the Library of Congress, two additional electronic databases were included: Educause, and Emerald Library. The review of literature search also included using the Internet (Google Scholar) to search for journal articles and books. However, there were a few journal articles found in Google Scholar that required purchasing. Those journal articles were searched in the Thoreau Multiple Database at Walden University. If I was unable to gain remote electronic access to these articles, I accessed them by visiting the physical libraries (public libraries, collegiate libraries, and the Library of Congress) in the local area. This literature research occurred from May 2011 to May 2013.

The Textbook as a Learning Object

In order for college students to learn the material in a course, faculty rely heavily on the course textbook(s) when providing instruction (McFall, 2005; Philips & Philips, 2007). The majority of college faculty members believe the required knowledge of the discipline can be found in the course textbook (Yonker & Cummins-Sebree, 2009; Zechmeister & Zechmeister, 2000). This belief leads college faculty to assign students reading assignments from the textbook and expect the weekly or daily reading assignments to be accomplished before students attend the course lecture (Hoeft, 2012; Ryan, 2006). Textbook reading improves reading skills and command of the course content (Park, 2013; Ryan, 2006). The ability to facilitate learning of subject content is accomplished through the textbook's design. The instructional designs of textbooks cater to a variety of learning styles. Integrating textbooks with graphs, charts, and pictures is done to attempt to address a variety of learning styles (Pugh, Pawan, Antommarchi, 2000).

Today's textbooks provide students with an opportunity to receive supplemental course content through Internet sites, CDs, DVDs, and other media technologies.

Supplemental course material, including the textbook, provides students with opportunities to further learn and understand course material that is covered during course lectures. Faculty often requires students to use these supplemental learning tools outside the course lecture, but not during the course lecture. There are a number of reasons as to why faculty rarely use these tools during the course lecture, but one such reason may have more to do with colleges and universities use of the Carnegie credit hour framework than personal preference (McCormick, 2011).

The Carnegie credit hour not only provides a framework for face-to face instruction, but also a framework for the out-of-course preparation (studying) needed by college students in order to be academically successful in the course. The purpose of the Carnegie credit hour is a recognized metric for colleges and university courses; the courses will have a prescribed amount of time allocated for instruction, student course preparation, and assignment completion (McCormick, 2011). Further, the Carnegie credit hour states that, for every one hour of classroom instruction, students should be spending, at a minimum, two hours outside of the course, either preparing for upcoming lectures or completing course assignments (Babcock & Marks, 2010; Laitinen, 2012; McCormick, 2011; Stratton 2011). Below is a chart (See Table 1) that represents the required number of hours, based upon student enrollment hours, a student should be engaged with the course material outside the course.

College students who are investing more time with the course content outside of class will often obtain better grades in the course (Brewster & Fager, 2000). Although the majority of colleges and universities have designed their courses around the Carnegie credit hour formula, it does not appear that today's college students are adhering to the

Carnegie credit hour format (Arum & Roska, 2011). In order for an undergraduate college student to be considered full-time, the student must be enrolled in at least 12 semester hours of credit courses (Laitinen, 2012). Applying the Carnegie credit hour formula to a full-time college student, the student should be spending 24 hours each week, at a minimum, engaged with the academic content outside of the course lectures when enrolled in 12 credit hours of courses (Laitinen, 2012; NARA, 2010).

Table 1

Carnegie Credit Hour & Study Hour Equivalency Chart

Semester Course Registration	In-Class Time Each Week	Out-Of-Class Time Each Week	Out-Of-Class Time For the Semester
3	3	6	96 hours
6	6	12	192 hours
9	9	18	288 hours
12	12	24	384 Hours
15	15	30	480 hours
18	18	36	576 Hours

Note: Information in this table is based upon a 16-week semester schedule.

A student who spends between 20 and 40 hours per week studying is spending an equivalent amount of time to workers in part-time, and even full-time, jobs. Twenty-four hours is the minimum amount of time that students should be spending on engaging with course material outside of the classroom (Laitinen, 2012; NARA, 2010). When attendance for 12 semester hours is coupled with the 24 hours of outside-of-class study required for the 12 semester hours, it is clear that attending college full-time is equivalent to a full-time, although unpaid, job. However, according to Yonker and Cummins-Sebree (2009), 60% of the students are not reading their textbooks more than one time outside of the classroom in a single week, and only engage in an average of six hours of study per week outside of the classroom for all of their classes, combined (Arum & Roska, 2011).

With the course textbook being an integral part of college courses, there has been a serious decline in the amount of time students are engaging with academics outside the course (Arum & Roska, 2011). Limited engagement with required textbooks severely affects the student's ability to master the course material (Brint & Cantwell, 2010). Research indicates that a number of college students are not spending enough time engaged in studying with their textbooks (Culver & Morse, 2012; Yonker & Cummins-Sebree, 2009). Today's college students are only spending, on average, three hours a week engaged with the course material outside of a course lecture (Culver & Morse, 2012) even when a minimum of six hours of engagement is required for a three credit hour course (Babcock & Marks, 2010; Laitinen, 2012).

College students' participation in academic related activities outside the course lecture has been consistently dropping since 1960 (Arum & Roska, 2011). This decline has occurred regardless of the student's major or type of college or university attended (Babcock &Marks, 2011). In 1961, students spent, on average, 20 hours a week studying, compared to 14 hours a week in 2003, but this reduction in study time has more to do with the types of students attending college today, with more students working jobs than previously (Babcock & Marks, 2010). However, for all types of students, the results of research suggest that students have reduced study time in order to gain leisure time for other activities (e.g., social activities) (Babcock & Marks, 2010). The 10-hour reduction in study hours has transferred from the academic-related activities to social activities, including playing videogames (Babcock & Marks, 2010). Arum and Roska (2011) also found similar results in their study.

Excluding the online students, the National Survey of Student Engagement (NSSE) determined that most university students were spending just under 15 hours a week when enrolled as a full-time (12 credit hours or more) student (McCormick, 2011). When students invested their time in studying, studying had a strong correlation with academic performance during the classroom instruction (Brint & Cantwell, 2010). Toreenbeck et al. (2010) found that, when college students invested more time in employment rather than studying, those students actually earned far less college credits than those students who did not. Guillaume and Khachikian (2011) found that high-performing students overestimated the time needed to earn an A in the course, but still maintained an average of six hours per week of outside engagement with the course's material. However, B students underestimated the amount of time on task needed outside the course in order to get an A (Jensen & Moore, 2008). C students decreased their outside engagement with course material, with a severe drop off in engagement occurring just before the midterm of a course (Guillaume & Khachikian, 2011).

Challenges with the Traditional Textbook

Although modern textbooks may be an efficient learning tool, some modern textbooks appear to be failing to elicit the interest of college students. According to Astin (1984), "The theory of student involvement argues that a particular curriculum, to achieve the effects intended, must elicit sufficient student effort and investment of energy to bring on the desired learning and development" (p. 522). Astin's comment begs the question as to why colleges and universities are not demanding a textbook design that would elicit student engagement, particularly outside the course.

It is during the out-of-class time when college students need to be using the textbook, however, some researchers have found this not to be the case. Yonker et al. (2007) found that a third of college students read less than 25% of the assigned reading in the course textbook. Another study found that a number of college students gave up after only reading a few pages due to having trouble comprehending the information (Ryan, 2006; Yonker & Cummins-Sebree, 2009). Those students who do manage to read the textbook will use a variety of strategies to get through the textbook reading. Many high-performing students will use the sinking strategy, which is intentionally trying to understand the textbook content (Fitzpatrick & McConnell, 2009). However, many low-performing students will either skim through the textbook chapter(s) or wait until the actual lecture to understand the textbook content (Baier, Hendricks, Warren-Gorden, Hendricks, & Cochran, 2011; Steuer, 1996; Yonker & Cummins-Sebree, 2009). Research has shown that a college student's lack of academic achievement is often due to the student's inability to invest their mental effort and time on task outside of the course (Duckworth & Seligman, 2005). Student involvement theory provides the theoretical insight as to why mental effort and time on task are vital components for students to be academically successful when attending college.

Astin's Student Involvement Theory

Student engagement appears to be one of the most researched areas within higher education (Tinto, 2007; Schreiner & Louis, 2006). According to Kuh (2009), student engagement is how students are investing their energy into college activities. The areas associated with student engagement center on student retention, persistence, and learning. Kuh summarized student engagement in the following statement:

> The engagement premise is straightforward and easily understood: the more students study a subject, the more they know about it, and the more students practice and get feedback from faculty and staff members on their writing and collaborative problem solving, the deeper they come to understand what they are learning and the more adept they become at managing complexity, tolerating ambiguity, and working with people from different backgrounds or with different views (p. 5)

Although academics (e.g., GPA, course grades, and learning, etc.) are an important element of student engagement, the research has focused primarily on either student engagement with the non-academic (e.g., athletics, student organizations, etc.), or college activities (Krause & Coates, 2008) or studies that demonstrate a correlation between non-academic activities and academics (Arum & Roska, 2011). Astin (1985, 1999) argued that, when it comes to academics, institutions have a tendency to focus mainly on three areas: subject matter, resources, and individualized instruction. According to Astin, subject matter theory is about the curriculum being taught by world-class faculty, and resource theory is about creating world-class facilities and/or having cutting-edge technology at the institution. Astin's use of the term "world-class faculty" are those faculty members who have been elevated, within their discipline, to the national stage based upon their scholarly work within their perspective discipline, whereas the term "world-class facilities" refers to those facilities which contain either current and/or innovative technology along with well-trained staff to assist the student (Astin, 1985). According to Astin, individualized instruction focuses on tailoring a degree program towards the college student's interest. Astin further argues that these theories (subject matter, resources, and individualized instruction) only work when there has been active participation on the student's part.

Generating active participation by the student is the basic premise of student involvement theory. This basic premise is evident in the five major principles specified by Astin (1985):

1. "Involvement includes the use of physiological and psychological energy towards an object
2. Involvement always happens along a continuum
3. Involvement is characterized by quantitative and qualitative features
4. The amount of student learning and personal development associated with any education program is directly proportional to the quality and quantity of student involvement in that program
5. The effectiveness of any education policy or practice is directly related to the capacity of that policy or practice to increase student involvement" (Astin, 1985, p. 135-136).

Time on task (physiological) equates to the amount of time in which students are actually engaging with an object, and mental effort (psychological) equates to the cognitive energy used while engaged with that same object. Although the level of intensity can vary, for this intensity to be positive in the learning or development process (See Figure 1), the level of intensity by the student should not vary (four hours this week but ten hours the next week) but should be continuous from week-to-week throughout the entire period (Roberts & McNeese, 2010). The third principle of student involvement theory states that student involvement does contain quantitative and qualitative properties that allow mental effort and time on task to be measured.

Astin (1985, 1999) argued that student involvement mainly concerns itself with student performance rather than the educator methodology, but does not discount the role of the educator in the learning process. A correlation between student engagement and achievement exists, but that correlation often gets lost among the other educational initiatives at a college (Brewster & Fager, 2000). First, Astin argues that curriculum is policy, or at least part of it, and the delivery of course instruction to students is practice. Second, this argument now infers that educators should be designing their assignments, learning environments, and the course content in a way that increases the student's mental effort and time on task, and also in a way that allows the increased time on task to be continuous and of quality.

Finally, student involvement theory's terminology is very different from what has been normally represented in the scholarly literature. Student involvement theory represents student's time on task as physiological intensity and the student's mental effort as psychological intensity. The concept of student's 'time', as it pertains to learning, has been discussed since the second decade of the 20th century (Karweit, 1982; Karweit, 1984). Other terms used in the literature to represent the concept of student time include vigilance, self-regulation (Barnard-Brak, Lan, & Paton, 2010), time management (Balduf, 2009; Dalton & Crosby, 2011), and time on task (Karweit, 1982; Nickerson & Kritsonis, 2006; Brint & Cantwell, 2010; Dalton & Crosby, 2011).

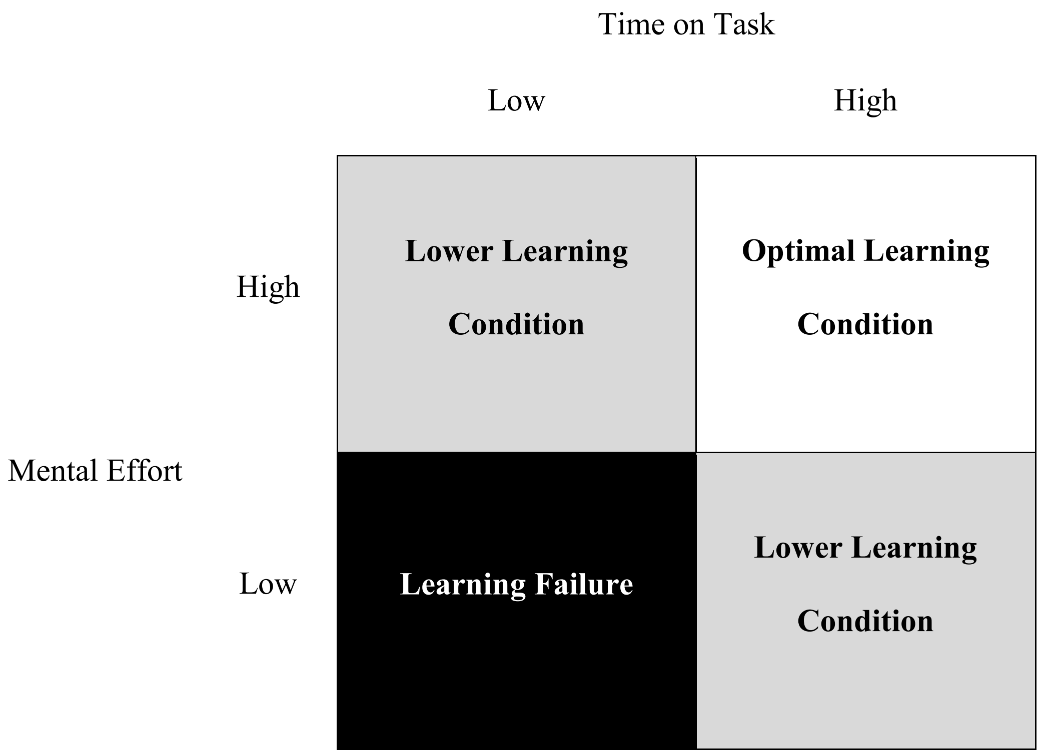

Figure 1. A pictorial depiction of Astin's student involvement theory.

Other terms used in the literature to represent the concept of student attention were quality of effort (Pace, 1982; McCormick, 2011) and mental effort (Paas, 1992). Student involvement theory also makes consistent reference to the term 'object'. Student involvement theory includes the term 'object' in the same way Algebra uses the variable 'x' to represent the unknown within an algebraic equation. In the case of student involvement theory, 'object' refers to the variety of experiences by college students who are enrolled in college. According to Astin (1985, 1999), the experiences of college students are wide-ranging and detailed. Wide-ranging college experiences may include on-campus employment, participation in student clubs, and learning communities (Torenbeek, Jansen, & Hofman, 2010), and detailed experiences may include student's research techniques or course preparation (e.g., assessment, assignments, or studying) (Astin, 1985; 1999).

Application of Astin's Student Involvement Theory to Non-Academic Activities

College students have a number of activities competing for their time (Kuh, Gonyea, & Palmer, Stratton, 2011). Student involvement includes not only academic activities but non-academic activities as well. Students are engaged in non-academic-related activities at three times the rate of academic-related activities (Brint & Cantwell, 2010). Student participation in non-academic activities does have a positive correlation with academic achievement (Roberts & McNeese, 2010).

In a study by Delaine et al. (2010), the researchers focused on increasing student participation within the global community of engineering students. The researchers utilized the Student Platform for Engineering Education Development (SPEED), an international organization that caters to the diverse student population in engineering education (EE). Delaine et al. (2010) claimed that student involvement in EE occurred on four levels: during the course, at the university, on the national stage, and on the international stage. Student participation declined gradually as students began to progress from the classroom to the international level.

The Global Student Forum (GSF) is the forum SPEED uses to increase student involvement in global engineering activities by encouraging students to create action plans (APs). To determine if GSF had increased student involvement, the researchers created a survey that was distributed before and after the annual conference. The results of the survey showed that there was an increase in the amount of student involvement, particularly in South America and Asia. There was a significant increase in the number of

APs presented in the year that the study was conducted relative to APs presented in the prior year. In addition, new forums were created in Australia, Mexico, and India. The student involvement initiatives by GSF created student partners in the global community of EE. It is important to point out that the study used “student involvement” as a way to evaluate whether or not GSF methods and practice had increased engineering students’ actual participation in international matters. The fifth premise of student involvement theory does call for programs and practices to be evaluated on the basis of whether or not those policies and/or practices have increased the mental effort and time on task of students in a way that is continuous and of quality. The third premise of student involvement theory states that student involvement has both quantitative and qualitative elements Astin (1985, 1999), which was included in the design of the survey. However, “student involvement” in Astin’s study was not the theoretical framework for the study, but was to assist readers in understanding the actual purpose of the study.

The study by Roberts and McNeese (2010) looked at the active participation in non-academic college activities of those students who transferred into four-year institutions versus those students who enrolled directly into the institution. These researchers made the argument that although academic success is important for student retention, equally important is student involvement in areas outside of academics, e.g. Greek life, service learning, art, athletic events, and activities that promote diversity. The study only included participants who graduated with bachelor degrees.

Roberts and McNeese (2010) concluded that students who did not transfer into the institution were much more involved in non-academic activities than those students who had transferred in. Students who transferred from a community college to a four-year institution were more involved in non-academic activities than students who transferred from other four-year institutions. The Robert and McNeese study demonstrated how student involvement theory is often used in conjunction with other theories, including Tinto’s retention theory and Schlossberg’s transitions theory. However, the lead-in given by the researchers started with graduation rates and pointed out that approximately 40% of the undergraduate students at public institutions are not graduating within six years of initial enrollment (DeAngelo et al., 2011; Knapp, Kelly-Reid, & Ginder, 2012). After a successful transition to the college environment, many college students’ participation in social activities causes a drop in actual credits earned during the academic year (Torenbeek et al., 2010). Little research has been done on how non-academic related activities distract college students from engaging with their academic studies (Brint & Cantwell, 2010). Astin (1984) argued that higher education institutions have not recognized that the student’s ‘time’ is also a valuable resource and, just like other resources, it is finite.

Arum and Roska (2011) argued that students have been much more engaged in the non-academic activities than their academic activities. Colleges and universities have inundated students with non-academic activities and social events, which may conflict with their academics (Dalton & Crosby, 2011). College students’ GPA decreases as students begin to increase their engagement in non-academic related activities (Brint & Cantwell, 2010). One of the keys to college success is the ability for the student to self-regulate, which is something that a number of college students seem to struggle with when it comes to studying (Dalton & Crosby, 2011). The majority of college students believe that academic activities (e.g., reading, studying, etc.) associated with the course are “very demanding,” and college-sponsored events (e.g., art, athletics, etc.) are tranquil activities in the college environment (Arum & Roska, 2011). Although student involvement theory is very applicable to non-academic activities, which is outside the scope of this research, student involvement theory can be applicable to academic related activities as well.

Application of Astin’s Student Involvement Theory to Academic Activities

The college activities have influenced students to participate in group study rather than individual studying (Dalton & Crosby, 2011). Arum and Roska’s (2011) study found that students studying alone performed better than students who participated in group study. Although the amount of learning-during academics-is dependent upon active participation by the student (Long, 1983), a study by Toreenbeck et al.(2010) found that time investment had an effect on student achievement. Howard (2005) and Guillaume and Khachikiane (2011) found time on task is not enough for students to earn decent grades in a course. What is missing from both studies was the second part of student involvement theory’s first premise, mental effort.

Student involvement theory’s first premise is the need for time on task and mental effort to occur simultaneously and not independently of one another. Research also shows that when students engage with the course material it will have a significant impact on academic performance (McCormick, 2011). Regardless of the impact, positive or negative, Astin (1984) would argue the impact was due to the consistency (student involvement theory’s second premise) of the mental effort and time on task by the student. For instance, Guillaume and Khachikiane’s (2011) found that students dedicated enormous amounts of time on task at the beginning of the course but time on task dramatically declined as the course progressed. This decline refers to the consistency being negative instead of positive. If there was positive consistency occurring, the amount of variation week to week would vary little during the entire course period. In other words, hours of student engagement with the course content would be roughly the same from week to week. To determine the amount of mental effort and time on task that occurs during engagement, quantitative and qualitative measures (student involvement theory's third premise) should be used.

Studies on Mental Effort and Time on Task

In a quantitative study by Um, Plass, Hayward, and Homer (2012), the researchers wanted to determine if positive emotional design had an impact on student learning. Emotional design involves the application of visual design effects, including color combinations and visual shapes, to impact learners' positive emotions (Um et al., 2012). Mental effort is often called cognitive load (Paas, Renkl, & Sweller, 2003; Um et al., 2012) and was termed cognitive load in this study. Although this study's major focus was investigating intrinsic and external positive emotional icons' influence on learning, the focus on cognitive load (mental effort) and motivation/persistence (time on task) is relevant to this research. In this study, cognitive load (mental effort) was operationalized as the level of mental effort required by the learner to learn the academic content. The intervention in this study consisted of an interactive multimedia format that displayed either neutral icons (shapes) or positive icons (shapes integrated with smiley faces), and the academic content contained in both formats was identical. In the area of mental effort, the researchers found that positive emotional icons increased the participants' mental effort when learning the academic content. The researchers were also able to identify an increase in participants' time on task. This increase was evident during the introductory phase of the study and also when the intervention was in progress.

Although the study focused on mental effort and time on task in isolation of one another, the study also investigated them in combination; they found a significant effect in the comprehension of the academic content. Um et al. (2012) demonstrated the potential of an interactive media learning tool to increase both time on task and mental effort. However, this study did not use an interactive multimedia learning tool that was designed using the digital game-based learning model, which means that the academic content was presented in a format that was similar to a non-digital format. Furthermore, the study was also designed utilizing a pre-determined time limit of one hour, which does not allow enough time to determine whether or not mental effort and time on task would be maintained over an extended period of time.

In the study by Patron and Lopez (2011), consistency, motivation, marginal learning, and student effort played a role in student grades in an online microeconomics course. The study is important to the current research study because Patron and Lopez focused on time on task as it related to student performance for students taking an online college course. The researchers wanted to determine whether study time or effort was responsible for academic success in a course and overall academic performance. The researchers found that student participation had a positive correlation with grades. The study found a 46% variation among student grades, which was 20% more than reported in the literature review conducted by the study. Patron and Lopez postulated that academic success in online courses was dependent upon time on task, but the intensity level must have a limited amount of variance. The researchers found that academic success is dependent upon students spending the same amount of time online each week throughout the course. Astin (1984) argued that intensity level must be continuous for both time on task and mental effort. Patron and Lopez (2011) also found that the amount of time students spent online in a course did not always correlate with high grades. In this study, 'studying smart' (mental effort) was more important than the amount of time the student spent online. The second part of Astin's first argument indicates that exertion of mental effort is needed for student success. However, mental effort was not addressed in Patron and Lopez's study.

Student involvement theory's major emphasis is generating increased mental effort and time on task when students are involved in activities that are of little interest to the student. When applied to academics, the faculty's role becomes very crucial to the student's learning process. It appears that Student involvement theory's fourth and fifth premises are just as relevant to course design and instruction as it is to program evaluation. In other words, college faculty should be designing courses and instruction that have the potential to increase the student's mental effort and time on task in such a way that these elements are not only continuous but also of quality. Interesting course assignments by educators have the ability to influence student engagement for longer periods of time, even to the point of completion (Brewster & Fager, 2000). Sargent, Borthick, and Lederberg (2011) found that viewing multiple short instructional videos caused students to invest mental effort and time on task voluntarily, but students viewed those tutorials based on their academic needs rather than the course needs. Low-performing students were voluntarily viewing the online tutorials at a slightly higher rate than the high-performing students (Sargent et al., 2011). If traditional textbooks are not eliciting mental effort and time on task, Astin would argue that administrators and educators should be focusing on methodologies that do. One such methodology may be Game-Based Learning (GBL).

Digital Game-Based Learning Theory

Game-Based Learning Theories

The concept of GBL has been around for well over a century (Juul, 2001; Moreno-Ger, Burgos, & Torrente, 2009). Over the past decade, there has been a lot of discussion about digital games and learning (Gros, 2007). Researchers have noted for many years that GBL is the future of learning in education, but have recently made the bold assertion that GBL will be central to education within one to three years (Johnson, Adam & Cummins, 2012). GBL is about using the power behind fun and play to engage students in the learning process (Johnson et al., 2012). Baek and Heo (2010) researched a variety of international journals to determine the current trends occurring in GBL. The search revealed a total of 89 research studies centered on context, methodology, and themes. GBL allows students to engage in game contexts and learning content, learn interactively through multiple learning methods, and provides two or more potential solutions to problems (Baek & Heo, 2010). When educators and instructional designers use game-based learning, it is mainly a tool for getting students to become engaged in the learning process. GBL includes all game formats, including paper-based games, board games, role playing games, and digital (video) games just to mention a few (Juul, 2001). Although most educators are open to using games in the learning process, some educators have not necessarily greeted the digital games format with open arms (Moreno-Ger et al.; Riegle, 2005). According to Amory (2007), this resistance may have more to do with an educator's ideology than with whether digital games are excellent learning tools. Although GBL is relevant to this study, GBL is not the appropriate model for the study (Prensky, 2001), because this research only concerned itself with digital games. This requires shifting the focus from the GBL model towards the Digital Game-Based Learning (DGBL) model.

Explanation of Digital Game-Based Learning Theory

Prensky's (2001) book, *Digital Game-Based Learning,* introduced the concept of DGBL. According to Prensky, DGBL is when the educational game is located online or on a computer. DGBL is about using key elements, like fun and interactivity, to generate continuous engagement for students accompanied by learning of educational content. Essentially, the premise behind DGBL is about merging game design with instructional design. "A DGBL game should feel just like a video or computer game, all the way through. But the content and context will have been cleverly designed to put you [the student] in a learning situation about some particular area or subject matter." (Prensky, 2001, p. 146)

The DGBL model puts game design before instructional design. Prensky (2001) quoted Ashley Lipson's argument that engaging educational games require designers to not begin with the content (educational) first, but the game first, which goes against the traditional wisdom. Prensky is subtly reminding educators/instructional designers that, regardless of how pedagogically and instructionally sound the learning tool, the tool is useless if the tool is not eliciting engagement by the student. DGBL accomplishes this by ensuring the internal structure of the learning tool utilizes the major elements found in a variety of popular digital games. According to Prensky (2001) and Dziorny (2005), those major digital game elements are: a. rules, b. goals and objectives, c. outcomes and feedback, d. conflict/competition/challenge/opposition, e. interaction, and f. representation or story.

Although the DGBL approach is unconventional for many educators, some educators appreciate and value the model. Some researchers believe that the DGBL approach may elicit increased mental effort and time on task. Gros (2003) pointed out that educators are often the ones who choose the course content, whereas digital games are mostly chosen by the players. DGBL's priority is not about putting engagement over learning or learning over engagement, but to ensure that both occur simultaneously (See Figure 2) within the digital game and with high intensity (Prensky, 2001).

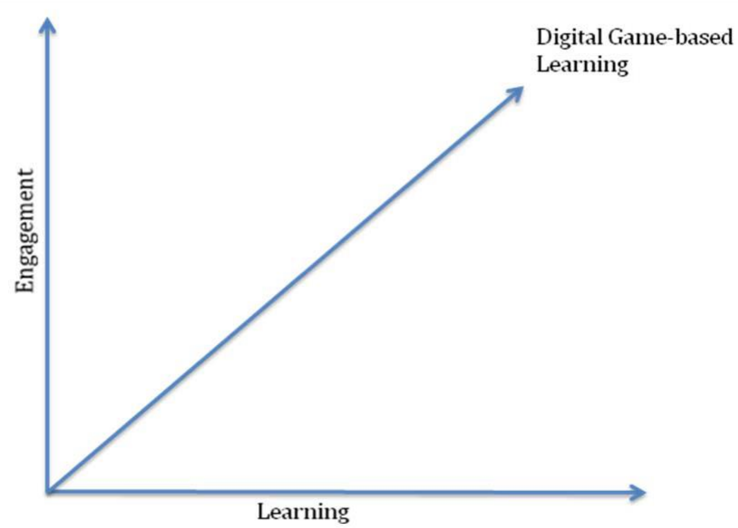

Figure 2. The relationship between engagement and learning in digital game-based learning. Adapted fromRelationship between Engagement and Learning Prensky, 2001, p. 150.

Gee (2005) was interested in how game designers are able to get players to play their lengthy, intricate, challenging games. Not only do players do this voluntarily, but

Gee claims the players do so happily. Gee (2005, 2007) discovered that digital games are designed around a set of problems that need solving and game designers are unconsciously aware they are using a variety of pedagogical and instructional techniques as well as engagement strategies. Even more important, Gee noticed that game designers are masters at using these techniques and strategies to get the players to voluntarily solve these problems.

Digital games contain several pedagogical methods that are very familiar to educational psychologists, making digital games potentially excellent teachers (Dickey, 2005a; Murphy et al., 2001). Problem-Based Learning (PBL) is one such method. PBL is when students learn from solving real-world problems as a way to learn the subject matter (Panoutsopoulos & Sampson, 2012; Whitton, 2010). Gee (2005) also found that many digital games have design environments in which situated and experiential learning can occur, often in conjunction with scaffolding. Scaffolding allows players to repetitively learn a particular skill or set of skills to the point of mastery, a technique known as reinforcing (Gentile & Gentile, 2008) or mastery learning (Gee). Also included in digital games are a number of finely-tuned assessments that have been integrated into the digital game learning process (Moreno-Ger et al., 2009; Shute, 2011). Gee (2005) argued that game designers are masters at putting learning theory into practical terms because designers need to get people to play the digital games. However, the point of Gee’s research was not to point out every instructional and pedagogical technique, model, and theory found in digital games (Gee, 2003, 2005, 2007). The purpose was to make the argument that digital games have the ability to increase the mental effort and time on task of its players, as well as ensure that intensity is continuous and of quality. However, the research did not include the completion of empirical studies to test these assertions.

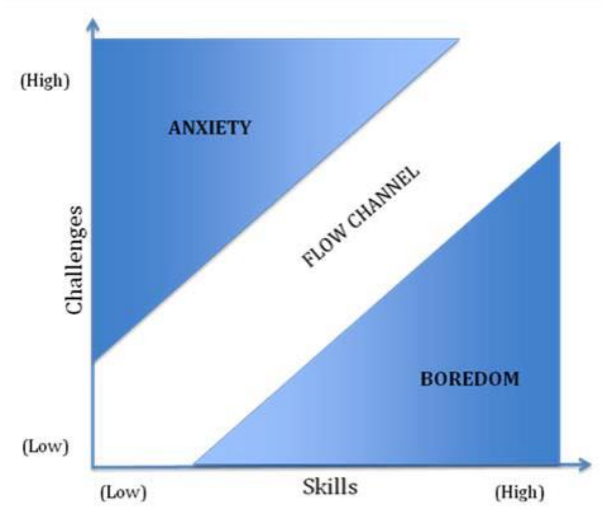

Figure 3. A diagram of flow experience (From: Csikszentmihalyi, 1990, p. 74; Dignan, 2011, p. 7).

There are a variety of techniques used by digital games that DGBL capitalizes upon. Many popular digital games have successfully used game design to provide an intricate balance during gameplay between very hard and very easy (Prensky, 2001). Gee (2005) referred to this feeling as pleasantly frustrating. For game design, including DGBL games, this is known as creating a "state of flow" (Moreno-Ger et al., 2009; Pavlas, Heyne, Bedwell, Lazzara, & Salas, 2010). Csikszentmihalyi (1975, 1990) argued there is a cognitive state in which a person actually loses total awareness of the time and the world around them because of such deep concentration on a current task. (See Figure 3). According to Csikszentmihalyi (1990), during the "state of flow," individuals are performing at an optimal level during the current task; even a task in which there was prior difficulty is now completed with ease.

Prensky (2001) and Gros and Garrido (2008) argued that DGBL games should also be very attractive to non-students and interest in playing digital games is likely to spread quickly through word-of-mouth. Furthermore, the students’ knowledge or skills in the content area should be increasing rapidly as game play increases, and after game play students should be reflecting upon what was learned in the game. Essentially, when pedagogical, instructional, key digital game elements, and flow theory are present in DGBL, it becomes very evident that the five premises of student involvement theory are present. In one way, DGBL is the end result of student involvement theory. The DGBL model allows the digital game to become the object in student involvement theory. The digital game’s design elicits the increased level of mental effort and time on task within the student, but the “state of flow” is what causes that intensity to be continuous while ensuring it is of quality.

Studies on Digital Games and Education

Ke (2008) conducted research on computer games and learning. Ke’s literature review revealed that the majority of research focused on students learning conceptually rather than students learning deeply about the subject matter. Ke designed a study to investigate whether or not digital games could allow students to meet the learning objectives of a math lesson. The digital games were then compared to traditional paper and pencil drills of the same content. Three hundred fifty-eight participants were recruited for this study and were divided into six different groups. Three groups used the traditional worksheets, while the three remaining groups used mathematical digital games that contained digitized worksheets. The groups were paired in three different sections: competitive, individual, and cooperative.

The results of the study found that digital games were more effective at increasing student motivation (Ke, 2008). Although this study used digital games in the learning process, the study is different from the proposed study in several ways. First, Ke's study used digital games in an elementary school learning environment; this research study is focusing on students in the college environment. Second, the Ke study used digital games as a planned in-class assignment, rather than an outside class assignment, which gave the participants only 45-minute interventions. This current research study is focusing on out-of-class student involvement. A 45-minute intervention makes it difficult to determine if there was an increase in time on task. Although competitive and cooperative gameplay can increase time on task, individual work is more similar to textbook reading by the student in a college environment than an elementary school environment. Determining whether a digital game-based textbook is more effective than a traditional print-based textbook for getting college students to exert time on task to reading of the course textbook is one of the underlying purpose of the current research study. Finally, Ke's study excluded mental effort intensity of the students during the learning process. This is evident when Ke mentioned that the digital games used were actually designed for students to practice prior knowledge and not to acquire new knowledge. Although there can be an increase of time on task during practice, this research study is focused on testing mental effort for college students acquiring new knowledge.

In 2012, Panoutsopoulos and Sampson conducted a study that used a commercial off-the-shelf (COTS) digital game for the purpose of achieving educational goals. The researchers found the COTS (SIMS: Out for Business) did allow students to achieve the general educational objectives and was just as effective as the traditional approach of achieving the mathematical educational objectives. More importantly, the researchers found that both educationally specific and entertainment-specific digital games can allow educators to reach mathematical educational objectives. Prensky (2001) argued that digital game-based learning is about a digital game having the ability to coincide with current commercial digital games. This can be accomplished through a number of different avenues. The easiest avenue is to find a commercial off-the-shelf digital game that will present the required educational objectives within the gameplay itself. The participants in this study did report having a positive experience playing the game. However, the participants' limited engagement with the game did not allow the participants to fully understand the relationship between abstract mathematical concepts and real-world scenarios. However, this research did not focus on college-age students (18 and older), but 13- to 14-year-olds. Another aspect that does not pertain to the current study is how the study used a COTS digital game with a traditional subject (math), but not from the heavy content disciplines such as sociology, anthropology, or psychology. The research by Panoutsopoulos and Sampson (2012) found that the participants were not able to make the connections between abstract concepts in math and real-world scenarios.

Manley and Whitaker (2011) conducted a study to determine whether or not Active Video Games (AVG) are an effective methodology for engaging college students to learn "sports performance" content during a sports psychology module. The non-AVG seminars were fun compared to the normal routine of learning, but the AVG seminars proved to be much more engaging (Manley & Whitaker, 2011). AVG used digital games that were designed for home consoles (Nintendo, Xbox 360, PlayStation 3) that utilize the motion sensor interface controls (Wii, Kinect, & Move) that connect to the home console. This study divided four seminar modules into two seminars that used an AVG complement and two seminars that contained a non-AVG component. Although each seminar contained interactive components, participants did not enjoy waiting for other students to finish participating with the AVG during the AVG seminar. In other words, the students felt they could have been doing something else with their time instead of standing by idly.

A key aspect in digital game-based learning is using digital games that allow students to remain in the "flow" (Csikszentmihalyi, 1975, 1990; Prensky, 2001). Although both AVG and non-AVG sessions allowed the students to learn pertinent information about sport psychology, the AVG session limited time on task for those students who finished sooner as they were forced to idly wait for slower students to finish before they could move to the next item in the module. This means time on task with learning content was reduced for some students as a result of the study's research design, rather than the student's personal decision. In the non-AVG seminars, students insisted that there needed to be more opportunities to engage with the course content, but the number of students participating in the non-AVG seminars did not allow for that to occur. This information implies that a number of students were willing to invest more mental effort and time on task towards learning the course content in the sports psychology seminar, but this could not occur because of the time constraints of the seminar. In order for time on task and mental effort to increase, educators need to design learning opportunities that are not confined to time limits, potentially outside the course. The experiment within this research study focuses on providing participants an opportunity to master the subject matter by allowing participants to determine the amount of mental effort and time on task they are willing to dedicate to learning the course content.

Students seem to actually prefer to engage pediatric course content through digital game-based learning pedagogy rather than using the web-based flashcards (Sward, Richardson, Kendrick, & Maloney, 2008). The pediatric course content focused on the field of pediatrics, which is the branch of medicine that focuses on the development and care of children (Pediatrics, 2013). The responses by the participants to a questionnaire also revealed that the participants within the game group were more active during the learning process than the self-study group, particularly because of the instant feedback that occurred within the web-based game. Such immediate feedback is a key aspect of digital game-based learning. However, this study did not find any significant difference in student academic performance between a web-based gaming group and web-based flashcard group. Although there was no significant difference when it came to learning the pediatric course content between the two groups, there was a significant difference in the amount of time on task each group engaged with their particular form of intervention, as well as the amount of mental effort during the four-week intervention period.

Astin (1999) argued that learning and development require students to increase their level of mental effort and time on task, which did not occur equally between the different groups. When it came to time on task, the game group was only allotted one hour per week to engage with the web-based game, and the participants could only access the game via a conference room when a facilitator was present. The self-study group could access the web-based flashcards at any time via the web and reported spending an average of 3.5 hours per week using the flashcards during the four-week intervention period. For mental effort, the game group required active participation in generating a verbal answer, but the self-study group could generate an answer without requiring any amount of mental effort because the participants could simply click on the answer button.

Recently researchers (Adams et al. 2012) conducted a study that focused on testing whether the discovery and narrative hypothesis added to digital games allowed college students to meet the learning objectives in an undergraduate biology course. Adams et al. used a design that is similar to that proposed for the current research, as well as using digital game-based learning and the recording of mental effort and time on task of the participants. This study used a 3-D digital game (a modified version of the popular game Half-Life) for the two treatment groups, and a slideshow-only presentation (PowerPoint) for the control group. The treatment groups also viewed the same slideshow, but the slideshow was embedded within the modified 3-D digital game. The only difference between the two treatment groups was one treatment group played a version of the game that contained a narrative (storyline), and the other treatment group's game did not contain a storyline (Adams et al., 2012).

In addition, this study involved two different experiments. Experiment 1 measured retention, transfer, difficulty, and effort. The first three categories are outside the scope of this study, but effort in this study related to mental effort, which is relevant to this research. The participants within the narrative game-based group reported having more mental effort when it came to learning course content, and the slideshow control group reported having the least mental effort, although there was no significant difference in mental effort between the groups (Adams et al., 2012).

In Experiment 2, Adams et al. (2012) recorded pretest and posttest scores and the time on task by the participants. Although there was no significant difference in learning between the two groups, the slideshow group had less time on task than both game-based groups. Of the game-based groups, the narrative game-based group had the most time on task. However, the problem with the study by Adams et al. was that mental effort and time on task were measured separately (two different experiments). Astin typically discussed mental effort and time on task in tandem. Astin emphasized that they work in combination. In the current study, they were measured in combination.

Rationale for Development of Digital Game-Based Textbook

Competition for student's time is not from another textbook, but from 3D digital games (Alsagoff, 2005). College graduates have spent, on average, 10,000 hours engaged in digital games during their time in college, but only half that time reading books (Pivec, 2009; Prensky, 2001). The question now becomes why should there be a digital game-based textbook in the first place? The answer to this question involves exploration of three areas: contemporary technology, game industry statistics, and college student interest.

Technologies for digital games have really advanced since the early days of digital games during the 1970s (Ip, 2008); the graphical interface, the processor, and the location of game play have changed (Gros & Garrido, 2008). Starting with the graphical interface, contemporary 3D graphic technology allows digital characters within the game to have life-like appearances, which is then integrated with a story to give the player a cinematic experience (Ip, 2008). However, the cinematic experience is possible because of the increase in processor speed. This is evident because current home console devices that are used for digital games also allow gamers to play DVDs or CDs, record TV shows, write music, and surf the internet (Ip, 2008). Wireless technology and the Internet allow digital games to be played online and even on Smartphones. Fifty-eight percent of gamers are using their Smartphone or handheld devices to play online games; 42% play games such as puzzle, board, card, or trivia games, and 25% play action, sports, strategy, and role-playing games (Entertainment Software Association [ESA], 2012).

This advancement in technology has allowed the game industry to become very profitable. People are spending enormous amounts of money and time on digital games (Gee, 2007). In 2004, the game industry surpassed the movie industry by $4 billion dollars (Riegle, 2005). Digital game sales during 2004 were around $10 billion in the United States alone (Eck, 2006). According to the ESA, digital sales have now increased to well over $23 billion dollars (Entertainment Software Association, 2012). ESA further claimed that 48% of those sales were from female buyers, and 52% of the parents believed digital games were having a positive impact on their children's lives. However, because the study was conducted by the Entertainment Software Association, it may be prudent to interpret these statistics with caution. Digital games have created an environment where digital game players are spending less time engaged in traditional media entertainment activities, such as going to the movies, watching TV, or watching movies at home. Gamers are now spending 50% less time going to the movies and 47% less time watching TV or movies at home (ESA, 2012). According to ESA, the top twenty digital game genres in 2011 were first-person shooter (FPS), role-playing, sports, and fantasy, with the exercise genre only pertaining to digital games. Although the best-selling and most popular games span many genres, common among these popular games is the ability to consistently keep players engaged. Digital game designers' primary focus is about keeping the players engaged (Prensky, 2002).

Over the past decade, the interest in digital games has been phenomenal, with digital games being introduced to more people, even those who were formerly non-gamers (Takatalo, Hakkinen, Kaistinen, & Nyman, 2011). According to (Riegle, 2005), students are spending around 11 hours per week on the computer just for fun. Game design is about connecting the player's experience to the digital game and, if done well, it will be an extremely passionate experience (Prensky, 2001). Digital games are powerful enough to engage students for hours on end, as well as on a daily basis (Prensky, 2001; Alsagoff, 2005). When a player is passionately engaged in the digital game, the player will often return daily, spending as few as 30 hours, to well over 100 hours, playing the game (Prensky, 2002). Shen & Williams (2011) pointed out that many of the massively multiplayer online (MMO) players spend on average 20 hours or more a week playing online games (e.g., World of Warcraft, EverQuest II, etc.). Over 70% of students earned their college degree after playing digital games in their off time during college (Riegle, 2005).

Sargent, et. al. (2011) found in their study that multiple instructional videos, few minutes in length, caused students to invest time voluntarily. However, students viewed the tutorials based upon their own academic needs, not based on the course requirements. They also found that low-performing students were voluntarily viewing the online tutorials and at a slightly higher rate than the high-performing students. If this is the case, when students begin having trouble with the course content, students are voluntarily seeking out other forms of instruction. This assistance often occurs outside of the course.

When textbooks are not enough to elicit the student involvement behavior within a student, administrators and educators look for alternative options to try and elicit that student involvement behavior.

Digital game-based learning is not about using a digital game for the entire learning process, but as a supplement to good instruction (Prensky, 2001). Digital games are used in the learning process because they are a very powerful motivator that can motivate students in a way other objects are not always able to do (Levy, 2007; Moreno-Ger et al., 2009). Kafai (2006) mentions how researchers, from the social sciences, are not only amazed at the amount of time on task people engage with digital games, but are also amazed at the amount of mental effort during that engagement. This is also evident from the current statistics from the digital game industry. Much of this has to do with current technology causing an increased interest in using digital games in education. Digital games for learning have been used in a variety of disciplines, including the medical field. Sward et. al. (2008) focused on using a web-based game to teach medical students the course content of a pediatric course. However, the majority of the literature focuses on using digital games inside the classroom/course, but not outside of the classroom/course. College students are very willing to engage in playing digital games outside of the classroom (Alsagoff, 2005; Moshirnia, 2007). This is evident by the number of college students who are spending a significant amount of their time engaged in digital game activities at the expense of academic studying. Prensky and Pivec (2009) pointed out that during the years spent completing undergraduate studies a number of college students actually spend around 10,000 hours engaged with digital games, but significantly less time reading. However, Gros and Garrido, (2008) argued that educational materials are chosen by educators and administrators, but digital games, on the consumer market, are mostly chosen by the students.

In conclusion, "quality of time on task must be investigated both from the standpoint of the teacher and of the learner" (Long, 1983, p. 19). It may be inferred from Astin's (1999) fourth and fifth premise of student involvement theory, that curriculum is a type of policy. With this in mind, course instruction is actually putting the policy in practice. Astin further argues that student involvement theory concerns itself with student performance rather than educator's methodology. However, it does not discount the educator's role in the learning process. When it comes to the learning process, Astin would state that educators should be designing assignments, learning environments, and course content not only in a way that increases the student's mental effort and time on task, but also in ways where that increased intensity is continuous and of quality. Educators can influence the levels of student engagement when it comes to course assignments; interesting assignments will often cause students to stay engaged with assignments longer and often to the point of completion (Brewster & Fager).

Summary

Each of the theories undergirding this study, Astin's student involvement theory and digital game-based learning theory, is examined in this chapter. Astin's student involvement theory posits that student engagement is characterized by time on task and mental effort (Astin, 1999). The premise of digital game-based learning theory is that game design with instructional design must be merged, and game-design is given priority over instructional design. According to Prensky (2001) and Dziorny (2005), the major elements of a digital game are: a. rules, b. goals and objectives, c. outcomes and feedback, d. conflict/competition/challenge/opposition, e. interaction, and f. representation or story. Digital game-based learning theory is about using key elements, like fun and interactivity, to generate continuous engagement for students accompanied by learning of educational content.

In this chapter, I also presented a review and synthesis of the peer-reviewed literature on college textbooks and challenges with textbooks, along with implications for the current study. Although modern textbooks may be an efficient learning tool, some modern textbooks appear to be failing to generate interest in college students. Research has shown that a college student's lack of academic achievement is often due to the student's inability to invest their mental effort and time on task outside of the course (Duckworth & Seligman, 2005). Although the course textbook is an integral part of college courses, there has been a serious decline in the amount of time students are engaging with academics outside the course (Arum & Roska, 2011). Limited engagement with required textbooks severely affects the student's ability to master the course material (Brint & Cantwell, 2010). Research indicates that a number of college students are not spending enough time engaged in studying with their textbooks (Culver & Morse, 2012; Yonker & Cummins-Sebree, 2009).

Although studies have been conducted on educational games and their relation to student learning (Adams et al. (2012); Alsagoff, 2005; Baek & Heo, 2010; Kiili, 2005, Pivec, 2009), no study was identified that looked at digital game-based learning theory and its relation to student learning of college course content. This study filled in the gap in the literature on digital game-based learning theory and its relation to student learning of college course content. This study also filled in the gap in the literature on research that focuses on increasing college student engagement with the college course textbook outside of lecture, as well as the gap in the literature on the efficacy of a digital game-based textbook for increasing student engagement with the textbook outside of lecture. Another gap in the literature is the dearth of studies that focus on digital game use with college students, and this study filled that gap in the literature.

From my review of literature, I inferred two possible solutions: a) combining digital games with a textbook and b) using a top-twenty digital gaming genre. I concluded that it may be useful for educators and instructional designers to explore designing educational/instructional digital games in the popular gaming formats and genres, which is the meaning behind DGBL (Dickey, 2005; Prensky, 2001). In the current study, I aim to evaluate whether a digital game-based textbook is more effective than a traditional print-based textbook in eliciting mental effort and time on task for college students. In the next chapter, the methodology for the current study is presented.

Chapter 3: Research Methods

Introduction

The purpose of this study was to determine whether there are significant differences in engagement as indicated by mental effort and time on task, based on the format of a textbook (traditional or digital game-based). This study is important because it determined whether an educational technology instructional tool effectively engages students in college course content outside of the structured environment of the college classroom. This chapter contains an examination of the choices that have been made related to methodological demands of this research question, including research design and approach, threats to validity, data collection, data analysis, and protection of research participants. In addition, the setting and sample, as well as procedures and instrumentation are discussed. In the threats to validity section, the reliability of scores and sample size demands are covered. At the end of this chapter, a summary of the methodological issues associated with this study is provided.

Research Design and Approach

The research design that was used in this study is quantitative. The quantitative approach is appropriate to use when the goal of a research study is to explain, describe, or evaluate phenomena of interest (Schutt, 2012). For this study, I aimed to evaluate whether a digital game-based textbook was more effective than a traditional print-based textbook in eliciting mental effort and time on task from research participants. The quantitative approach involves conceptualizing research and theory as deductive in nature and collecting numerical data (Bryman, 2012). Quantitative methods involve recording variation in variables in terms of quantities, and data obtained in quantitative research may be numbers or attributes that are ordered in magnitude (Sarafino, 2005). The independent variable for this study, textbook type, is categorical in nature. The first dependent variable, mental effort, is interval level in nature, and the second dependent variable, time on task, is ratio level in nature. The research question for this study requires a quantitative approach to answer. Neither a qualitative nor mixed method design was used for this study, because this study sought only to determine whether a causal relationship existed between an independent variable and two dependent variables. In scientific research, only the quantitative experimental research design may be used to determine whether a cause-and-effect relationship exists and to draw scientific cause-effect conclusions (Sarafino, 2005).

Research Question

The research question for this study allowed examination of the variables identified as relevant to student performance and textbook format. Specifically, for a sample of undergraduate college students, are there significant differences in engagement, as indicated by mental effort and time on task, based on the format of a textbook (traditional or digital game-based)? Two hypotheses stem from this research question:

Hypotheses

1. Null Hypothesis (H_0): There will be no significant differences in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based).

2. Alternative Hypothesis (H_A): There will be significant differences in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based), with students using the digital game-based textbook having demonstrated significantly more mental effort and time on task.

Research Design

This study used a causal-comparative research design. Causal comparative research focuses on examining differences between two or more groups (Lodico, Spaulding, & Voegtle, 2010). The causal comparative design is similar to the true experimental design, but is non-experimental and involves an independent variable that is not manipulated (Cohen, Manion, & Morrison, 2007). Although a true experimental research design focuses on differences between groups, as well as causality (Rosenthal & Rosnow, 1991), it was not be used because it requires the use of random assignment, which is not feasible for this sample. A correlational design was not used, because the independent variable and dependent variable both needed to be continuous, and the independent variable for this study was categorical. The causal comparative research design was appropriate to use, because it allowed me to conduct an examination of differences between groups (digital game-based textbook group and traditional print-based textbook group) to answer the research question for this study.

Setting and Sample

The participants were from the relevant population to address the research problem. The population of interest for this study was adult degree-seeking undergraduate students at a college or university, because the goal of this study was to determine the effect of undergraduate textbook format on mental effort and time on task. The sampling frame included individuals who were degree-seeking undergraduate students at a college or university and who were 18 years of age or older. Individuals under the age of 18 were excluded from participation in this study because the target population was limited to adults. In addition, obtaining and verifying parental permission from prospective study participants was not feasible.

A sampling strategy should include procedures that are practical and ensure that access to prospective participants is permitted (Cohen, Manion, & Morrison, 2007). Sampling strategies may be grouped into two categories, probability sampling strategies and non-probability sampling strategies (Bryman, 2012; Frankfort-Nachmias & Nachmias, 2008; Schutt, 2012). Probability sampling strategies (e.g., cluster, simple random, stratified, systematic) require compiling a sampling frame and selecting sample elements based on probability (Schutt, 2012). Compiling a sampling frame and selecting sample elements based on probability was not feasible for this study. It was not possible to generate a complete list or gain access to the complete list of individuals in the population of interest, which was individuals who are degree-seeking undergraduate students at a college or university and who are 18 years of age or older. A complete sample frame should include all sampling units in the population of interest (Frankfort-Nachmias & Nachmias; Schutt,). It was not feasible to generate a complete sample frame for the population of interest, all adult degree-seeking undergraduate college students, because I did not have the ability to gain access to the names or contact information of all adult degree-seeking undergraduate college students. For the reasons outlined, which include the inability to gain access to the names and contact information for each element in the complete set the population of interest and therefore my inability to assure that each element has a specified probability of inclusion in the sample, a non-probability sampling strategy was necessarily used.

Of the various non-probability sampling designs (e.g., purposive/judgment, quota, snowball), the convenience sampling strategy was most feasible and was used for this study (Frankfort-Nachmias & Nachmias, 2008; Schutt, 2012). The purposive/judgment sampling strategy was not appropriate, because it requires a researcher to select elements from the population of interest based on the element's unique position based on the researcher's judgment (Adler & Clark, 2011), and the sample would not represent the population of interest (Schutt, 2012). Quota sampling was not appropriate to use for this study, because that sampling strategy involves selecting elements from relevant subgroups based on their proportion in the population of interest (Adler & Clark, 2011) and no relevant subgroups for the population of interest were identified because I did not have access to a complete list of individuals in the population of interest. The prevalence of subgroups in the population of interest could not be determined, because I did not have the ability to identify or access a complete list of elements for the population.

Snowball sampling was also inappropriate for this study because it should only be used when individuals in the group of interest are used to identify other prospective research participants (Adler & Clark, 2011), and asking research participants to identify other research participants could have been exploitative. Also, this strategy could have resulted in unnecessarily extending the time period for data collection for this study. The most appropriate non-probability sampling strategy to use for this study was the convenience sampling strategy. Convenience sampling involves selecting elements to include in the sample, based on convenience to the researcher (Schutt, 2012). A convenience sample is acceptable to use to generate preliminary research that may be used as a springboard for future research (Bryman, 2012). The convenience sample used for this study was a nonprobability sample and like other nonprobability samples, it would be inappropriate to generalize the findings to the population of interest (Bryman, 2012; Schutt, 2012), although the results may have relevance for the population of interest.

Sample Size

Having an appropriate sample size minimizes the likelihood of a Type-I or Type-II error occurring when a statistical test is performed (Cohen & Cohen, 1983). Statistical power of .80 is the suggested convention for researchers to use when determining sample size (Cohen & Cohen). In addition, although an alpha level of .05 is a convention for significance in scientific research (Cohen & Cohen, 1983; Ellis, 2010), to determine the sample size for this research study a more conservative alpha level of .01 and power of .80 was used.

In addition to power and alpha-level, an effect size is needed to determine the appropriate sample size for this study (Cohen & Cohen, 1983). Barlett and Rodeheffer (2008) conducted two meta-analyses of studies that examined variables affected by digital game play. The meta-analyses examined more than 50 studies including both experimental and correlational research studies. The results of the meta-analysis examining 72 effect size estimates revealed a range of effect sizes for problem solving (r = .69), for skill acquisition (r = .52), and for attention (r = .34). This meta-analysis focused on digital game play and cognitive performance. The average effect size (.52) from these relevant studies was used to determine the appropriate sample size for this study.

A power analysis conducted using G*Power 3 (Faul, Erdfelder, Buchner, & Lang, 2009) software indicated that a total sample of 48 participants is needed with an alpha-level of .01, power equal to .80, and moderate effect size ($r = .52$, $\Delta = 1.15$) obtained in the discussed meta-analysis of similar studies. A comparison chart for social science researchers indicates that strength of association effect size of $r = .5$ is moderate and equivalent to a group difference effect size of 1.15 for Glass's Δ, Cohen's *d*, and Hedges *g* (Ferguson, 2009).

Instrumentation

Mental Effort Scale. The Mental Effort Scale or MES (Paas, 1992) was developed to measure mental effort, which is also known as intensity of effort and cognitive load. The MES was designed to be administered once, at the end of a learning task or experience (Van Gog et. al., 2008). The measure was originally tested for use with individual's ages 16 and older (Paas). Since then, at least 25 peer-reviewed studies have used the measure with a wide range of populations, with students frequently comprising these populations (Van Gog & Paas, 2008). The measure is self-administered and takes approximately 10 minutes to complete. Because of its psychometric soundness and ease of use, the MES has become the most widely used measure in this area of research (Paas, Tuovinen, Tabbers, & Van Gerven, 2003).

The MES utilizes five 9-point Likert-type items (See Appendix F). Scores are computed by summing participant responses for each item on the measure, with higher scores reflecting greater mental effort expenditure and lower score reflection lower mental effort expenditure (Paas & Van Merrienboer, 1994). Many research studies provide evidence of the reliability of MES scores with particular samples, most of which used Cronbach's alpha. Alphas have ranged from .82 to .93 in previous studies (Paas, 1992; Paas & Van Merrienboer, 1994; Van Gog, Paas, & Van Merrienboer, 2008; Kester, Kirschner, & Van Merrienboer, as cited in Van Gog et al., 2008).

Several research studies report evidence of the validity of MES scores. For example, students with higher MES scores expended significantly more mental energy than students with low MES scores as measured by the spectral analysis of rate (Paas & Van Merrienboer, 1994), providing evidence of the concurrent validity. Evidence of the concurrent validity of the MES has also been found in other studies (Van Gog et al., 2008), as well as evidence of construct validity, convergent validity, and discriminant validity (Gimino, 2000). Confirmatory factor analyses were also conducted to assess the factorial validity of the instrument, including the convergent and discriminant validity of its items. The results of a range of statistical tests including fit indices, the Lagrange Multiplier test, and Wald test provided further support of the validity of scores produced by the MES (Gimino, 2000).

Learning Resources Stopwatch Measure. The second dependent variable, time on task, was measured using researcher observation using a stopwatch. The computer screen of each activity session was recorded, so that each participant's time on task could be retrospectively assessed by viewing the recording after all data was collected. Researchers have used stopwatch measures to measure time on task (Brydges, Nair, Ma, Shanks, & Hatala, 2012). In the same manner used by Johnson and Christensen (2004), a stopwatch was the data collection instrument used for the quantitative observation.

Using the stopwatch measurements allowed for later coding of the data for time on task. This type of quantitative observation is typically used for confirmatory purposes, such as testing hypotheses (Johnson & Christensen, 2004). Reliability of quantitative observation is achieved using standardization of the entire set of observational procedures (Johnson & Christensen, 2004). In addition, I was the only person who utilized the Learning Resources Stopwatch measure to conduct the observation, thus adding to the reliability of these scores.

Questionnaire. A brief questionnaire that captured demographic data on participant characteristics was used. These data were used to determine to what extent the characteristics in the sample reflect the population of interest. The questionnaire content includes questions about age, gender, race/ethnicity, college level, and college work completed (See Appendix J). This questionnaire includes six items and takes approximately 5 minutes to complete.

Advantages and Disadvantages of Measurement Approaches

The MES and demographic questionnaire are both self-report measures. There are several advantages to using self-report measures, including greater efficiency, due to the need for less time and fewer resources than other data collection methods (Sarafino, 2005). This method of data collection allows for large amounts of data to be inexpensively collected in a relatively short period of time. In terms of time, self-report measures may be completed and scored in a short period of time, relative to direct observation, which can require longer periods of time. Another advantage of using self-report measures is that some covert variables (e.g., love) may only be studied using this type of data collection process (Sarafino, 2005).

The primary disadvantage associated with the use of self-report measures is the issue of accuracy. Self-report measures rely on the perception, memory, and recall of research participants (Sarafino, 2005). However, the extent of correctness of participants' memory is unknown, and participants may recall vague or incorrect memories (Sarafino, 2005). Another disadvantage is that, although self-report measures involve the attempt of researchers to gather information about the knowledge of participants, including participants thoughts, beliefs, and behavioral intentions (Johnson & Christensen, 2004), researchers attempts to collect such information may be thwarted by the intentional lying of participants. It was unlikely that vague or incorrect memories would be an issue for this study, because the MES focuses on the participant's experience immediately preceding its administration and questions on the demographic survey focus on facts about one's self that is likely to be known to the participant. It was also unlikely that lying would be an issue for this study, because there are no socially correct responses for the demographic survey or MES and participants have nothing to gain from lying.

The LRS is a structured observation measure. Structured observation has several important advantages and disadvantages. One advantage is that quantitative observation may be conveniently conducted via electronic recording device (e.g., stopwatch, video-tape recorder, etc.). Using electronic recording devices (e.g., video-tape recorder conveniently allows for accurate later coding of data (Johnson & Christen, 2004). As mentioned earlier in this chapter, the time on task variable was measured retrospectively using a video recording. A disadvantage of structured observation is the potential for data collection error, as a result of technological error (e.g., power-failure, electronic-recording device malfunction). Given the testing environment for this study, the possibility of data collection error resulting from technological errors is slight.

Threats to Validity

Demonstrating validity is an important goal of empirical research, because correct conclusions about empirical reality cannot be drawn without the goal of validity being obtained (Schutt, 2012). To draw correct conclusions, sound research should involve minimizing the threats to valid inference making. In this section, threats to internal validity and external validity are examined. Assuring measurement validity is discussed above in Instrumentation, and threats to conclusion validity are addressed below in Data Analysis.

Threats to Internal Validity

Internal validity is the extent to which the results can be appropriately attributed to the variables in the study, instead of other variables or factors (Sarafino, 2005). Randomization using random assignment without replacement was used to maximize the internal validity of this study. The dominant purpose of randomization is to maximize internal validity (Campbell & Stanley, 1963). This study is a causal comparative research study, not an experimental study, and most of the threats to internal validity associated with an experiment typically do not apply to a causal comparative research design (Martella, Nelson, Morgan, & Marchand-Martella, 2013). Typically the selection threat to internal validity is a concern, but other threats to internal validity are not as applicable.

However, three concerns were addressed to maximize internal validity: (a) a causal comparative research study should be heavily grounded in theory, (b) the selection threat should be addressed by using a high degree of precision in selecting the control and comparison groups, and (c) the statistical tests of significance utilized must be appropriate for the study (Martella et al., 2013). With respect to the first concern, this study was heavily grounded in theory, in particular Astin's student involvement theory and Prensky's digital game-based learning theory. The second concern has also been taken into account, and a high degree of precision was used to select the first and second groups. Each group was comprised of individuals with specific characteristics identified in the sample and setting section of this paper. In addition, each group's exposure to the independent variable was known and verifiable. Last, to address the third concern, appropriate tests of significance were used and are discussed in detail in the upcoming data analysis section of this chapter.

Threats to External Validity

External validity is the extent to which a study's results can generalize to groups or situations beyond those included in the actual study (Adler & Clark, 2011; Sarafino, 2005). Six threats to external validity are of possible concern with causal-comparative research designs (Martella et al., 2013). The first threat, generalization across participants, occurs frequently because researchers commonly used a convenience sampling strategy. This research study used a convenience sampling strategy, instead of a random sampling strategy. To address this concern, I acknowledge in the limitations subsection of the discussion of the results that the results of this study are unlikely to generalize across participants (Martella et al., 2013) or to the population of interest

(Bryman, 2012). However, demographic data was collected so that comparisons to the population of interest could be made, although results may not be scientifically generalized to the population of interest.

The second threat to external validity, verification of independent variable, has also been carefully considered and addressed in the study's research design. As suggested by researchers (Martella et al., 2013), the categorizing of participants for the independent variable (textbook type) is precise and there is no room for error in categorization. The third threat to external validity, posttest sensitization, was not applicable in this study's research design, because pre-testing that could sensitize participants to measures posttest was not utilized. The fourth threat to external validity, interaction of time of measurement and treatment effects, was addressed in this study's research design, with the dependent variable measurements of mental effort and time on task occurring immediately at the conclusion of each participant's exposure to the independent variable.

The fifth threat to external validity, measurement of the dependent variable, was minimized as a result of the use measures with good psychometric properties, as discussed in Instrumentation. To minimize the final threat to external validity, interaction of history and treatment, a researcher should not generalize study results to past situations, future situations, or individuals in other settings (Creswell, 2009). I followed these guidelines.

Data Collection

Recruitment of participants was conducted via community-based communications (e.g., flyers on bulletin boards in community sites). Before any data was collected from participants, I informed participants in an informed consent form that participation in the study was completely voluntary. Further discussion of human subjects concerns appears in Protection of Participants.

The research study was conducted in a controlled setting. A computer lab with individual workstations on a college campus and at a public library was reserved for multiple dates across the time needed for administration of this study. At each session, a digital game-based textbook activity session or a print-based activity session (See Appendix D) was conducted. Each computer lab used had individual workstations labeled with ID numbers. The computer screen of each activity session was recorded. When the activity session ended, the activity session data was saved with the ID number of the participant so that each participant's time on task could be retrospectively assessed by viewing the recording after all data was collected.

I randomly assigned participants to either the first group (print-based textbook group) or second group (digital game-based textbook group). Random assignment without replacement was used to obtain an equal number of participants in both groups. I placed 27 slips with the name dgbg (digital game-based textbook group) and 27 slips with the name pbtg (print-based textbook group) in small sealed envelopes. I drew a sealed envelope for each participant when the participant arrived to randomly assign each participant to the print-based textbook group or digital game-based textbook group.

I give a participant written instructions (See Appendix E) and then the participant began engagement with either the digital game-based textbook or the print-based traditional textbook activity session at an individual workstation labeled with an ID number. I followed a standard activity session protocol (see Appendix E). Participants were not limited to a minimum period of time for study participation. I expected that the majority of participants would complete the study in less than one hour.

When a participant indicated that he or she was finished with the activity session, the participant was given the Mental Effort Scale and demographic survey. I thanked the study participants for his or her research participation. After each the activity session concluded, a participants who was not in the digital game-based group was given the opportunity to view and engage in this activity, as suggested by Creswell (2009).

Data Analysis

Descriptive Statistics

Descriptive statistics were generated for this study. The raw frequencies for age, gender, race/ethnicity, year-in-college, game-play frequency, and year in college (e.g., freshman, sophomore, etc.) were tallied. The minimum, maximum, mean, standard deviation, skewness, and kurtosis were computed for this study's two dependent variables, which are mental effort and time on task. All descriptive statistics were screened for outliers and anomalies using trimmed means.

Green and Salkind (2011) noted that although a researcher can create scores for missing data by taking the mean of existing non-missing items, they do not recommend it. Outliers were excluded from the statistical analyses for this study. Excluding these data was appropriate, because it is necessary and appropriate to preserve the integrity of the results of the data.

Internal Consistency

Cronbach's alpha was used to determine the internal consistency of MES scores from this study's participants. This reliability check was conducted to address any problems with measurement precision for MES scores, due to unforeseen sources of error. An acceptable alpha, coefficient was considered to be .70 or higher (Yockey, 2011).

Data Assumptions

Discussed in more detail in the next section, the central statistical test that was used for this research study was Hotelling's T^2. The three data assumptions for this test are independence, multivariate normality, and homoscedasticity (Wiesner, 2006). The assumption of independence means that the participants for both groups were independently sampled (Wiesner, 2006). The procedures for this study were designed to ensure that participants for both groups are independently sampled to ensure that this assumption is not violated.

Normality is the second assumption and refers to the assumption that population distribution underlying the sample distribution is normal. Although Hotelling's T^2 test is not generally sensitive to violations of the normality assumption (Wiesner, 2006), diagnostic tests were performed. A histogram of the scores was used for each variable to check for a symmetric distribution. In addition, skewness and kurtosis was computed to determine whether the shape of the distributions is within the normal range. Homoscedasticity is related to normality, because if both dependent variables are in fact normally distributed, the resulting outcome will be homoscedastic (Bordens & Abbott, 1991). This assumption was checked by creating a scatterplot, as recommended by Bordens and Abbott. If the scatterplot is elliptical shape, then homoscedasticity is present. In contrast, if the scatterplot is conical shape, then heteroscedasticity is present.

Inferential Statistics

The inferential statistical test used to conduct data analyses for this study was the Hotelling's T^2 test (Wiesner, 2006). Hotelling's T^2 is appropriate to use when there are multiple dependent variables and two independent groups in a single independent variable–the digital game-based textbook group and traditional print-based textbook groups. In essence, Hotelling's T^2 can be viewed as the multivariate extension of Student's *t*-test, and as such, a more appropriate technique than two independent sample *t*-tests, due to inflation of Type 1 error. Further, because it is a multivariate technique, it has the power to detect differences in groups resulting from the combination of scores on the dependent variables (Wiesner, 2006), and the independent samples t-test only detects differences for a single dependent variable (Green & Salkind, 2011).

Ideally, the results of this analysis would support rejection of the null hypothesis. The multivariate Hotellings T^2 test may fail to detect a significant result when one or both univariate independent sample t-tests are significant, however, because correlations between the variables not taken into account with univariate t-tests are taken into account with the multivariate Hotelling's T^2 test (Hitchcock, 2012). The two univariate analyses could be significant when the Hotellings T^2 is not significant, when there are statistically impactful correlations between the variables. Because it was indicated, post hoc analyses were conducted to determine whether significant differences exist at the univariate level.. To control for Type I error resulting from post hoc multiple comparisons, the Bonferroni correction, the most popular method to control for familywise error (Field, 2009) was applied.

Protection of Participants

As Bryman (2012) suggested, I addressed the four primary areas of ethical concern in social research. I ensured that 1) no harm came to research participants, 2) informed consent was utilized, 3) no invasion of research participants' privacy occurred, and 4) deception was not be used at any point in the study. The participants in this study were not marginalized in any way. I fully divulged the purpose and contents of the study in the informed consent process (See Appendix B).

I obtained approval from Walden University's Institutional Review Board, before any data collection began. No participants from vulnerable populations were used in this study. All participants were at least 18 years of age. Participants were assigned identification numbers. Data gathered from participants during the study only included the participants' researcher assigned identification numbers. All of the identifying information of participants was kept confidential. The protection of participant data was ensured by keeping all participant data under lock and key. For further protection, the data was kept on USB drive(s) that are password protected. The data analysis process was characterized by honesty, which included testing of assumptions of the statistical tests utilized as well as honest data reporting. When the results of this study are written and disseminated, research participants, as well as the institution from which research participants are recruited, will not be revealed. The final research report will be disseminated to the dissertation committee members, Walden University, the College from which research participants are drawn, the scholarly community at large, as well as the general public.

Summary

This quantitative research study was conducted to determine whether there are significant differences in engagement as indicated by mental effort and time on task for students who utilized a digital game-based textbook and students who utilized a traditional print-based textbook. The causal comparative research design was used for this study. The research design and approach of this study was thoroughly discussed. The specific procedures for administration of this study were outlined.

According to Kirk (1995) valid inference making cannot be made when inappropriate statistical procedures are used. To minimize threats to valid inference making three conditions that can inflate the Type I error rate were addressed in this section. Those three conditions are reliability of the measures used for this study, meeting of the data assumptions for the selected statistical tests, and appropriate determination of sample size.

The instrumentation used for the study was identified and the soundness of the psychometric properties for each measure was examined. The results of peer-reviewed literature indicated that the MES has sound psychometric properties. The brief demographic questionnaire, as well as the Learning Resources Stopwatch measure to be used for measuring time on task, were discussed. The threats to internal validity, external validity, and statistical conclusion validity were examined and addressed in this chapter.

Statistical power, alpha level, and effect size using accepted conventions for social science research and the results of a recent meta-analyses of relevant educational studies, were used to determine the appropriate initial sample size ($N = 48$) for this study. The researcher identified appropriate measures to ensure the protection of research participants. The appropriate statistical tests and software needed to compute the results of the study were identified and discussed. Statistical software was used to conduct the multivariate Hotelling's T^2 test and post hoc analyses. The assumptions for each statistical test were identified and discussed.

Chapter 4: Results

Introduction

The aim of this study was to evaluate whether a digital game-based textbook was more effective than a traditional print-based textbook in eliciting mental effort and time on task from research participants. This approach was quantitative in nature with a causal-comparative design. The independent variable was defined as type of textbook (digital game-based or traditional print-based). The first dependent variable was mental effort, which is also known as psychological intensity. Mental effort was measured using the Mental Effort Scale (Paas, 1992). The second dependent variable was time on task, which is also known as physiological intensity (Astin, 1985, 1999). Time on task was measured using the Learning Resources Stopwatch measure. This chapter contains a description of the students who participated in the study and summarizes the analyses that were used to answer the research question.

Research Question and Hypotheses

A thorough examination of the problem and the research literature on this topic resulted in the following research question: For a sample of undergraduate college students, are there significant differences in engagement as indicated by mental effort and time on task, based on the format of a textbook (traditional or digital game-based)? This question led to the following hypotheses that were tested.

Hypotheses

1. Null Hypothesis (H_0): There will be no significant differences in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as

measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based).

2. Alternative Hypothesis (H_A): There will be a significant difference in engagement as indicated by mental effort as measured by the Mental Effort Scale, and time on task as measured by the Learning Resources Stopwatch measure, based on the format of a textbook (traditional or digital game-based), with students using the digital game-based textbook having demonstrated significantly more mental effort and time on task.

Data Collection and Reporting

The data for this study were collected over a 4-week period between March 2014 and April 2014. Participant recruitment was conducted via community-based communications, including flyers on bulletin boards in community sites (Appendix I). The research study was conducted in a controlled setting to reduce error and help ensure interpretable results. This setting consisted of an on-campus computer lab with individual workstations that was reserved for multiple dates across the 4-week study period. Prospective research participants met me at the reserved computer lab before the study began. All of the prospective research participants met the eligibility criteria for participation in the study. When a research participant arrived for an activity session, I first conducted the informed consent procedure. Before any data were collected from participants, I first informed each participant by issuing a printed informed consent form (Appendix B) stating that participation in the study was completely voluntary. After a participant read and signed the informed consent form, I randomly assigned the participant to a participant group.

A strategy of random assignment without replacement was used to assure an equal number of participants in both groups. I placed 27 slips with the name dgbg (digital game-based textbook group) and 27 slips with the name pbtg (print-based textbook group) in small sealed envelopes. Each participant drew an envelope on arrival, thus assuring random assignment to conditions of the independent variable. At that point, I gave the participants written instructions (see Appendix E), and they began the digital game-based textbook or the traditional print-based traditional textbook activity session at an individual workstation. I followed the standard activity session protocol (see Appendices K and L). Participants were limited to a maximum period of time for study participation, which was 2 hours.

Each computer lab used for study sessions had individual workstations labeled with ID numbers. The computer screen of each activity session was recorded. When an activity session ended, the activity session data were saved with the ID number of the participant. This tactic allowed each participant's time on task to be retrospectively assessed by viewing the recording after all data was collected.

When a participant indicated that he or she had finished with the activity session, the participant was given the Mental Effort Scale and demographic survey. After a participant completed these measures, I thanked the study participant for participating in the study. At this point, the participant's activity session had ended, and the participant was given a $10.00 gift card. There were no reports of adverse effects from participation in this study. After each activity session concluded, participants who were not in the digital game-based group were given the opportunity to view and engage in the digital game-based textbook activity, as suggested by Creswell (2009). After data were collected, they were entered and analyzed using NCSS, a comprehensive statistical and graphical analysis software for researchers (Hintze, 2013).

Sample

The respondent group for this study was comprised of 54 matriculated college students. Demographic characteristics for this study's sample appear in Table 2, and were compared to the students at the college from which the study sample was drawn and some national statistics on college students.

Table 2

Demographic Characteristics of Study Sample (N=54)

Demographic Variable	*n*
Age	
18-24	38
25-34	9
35-60	7
College status	
First-Year	26
Sophomore	28
Ethnicity	
Asian (not American)	2
Asian-American	4
Black/African-American	24
Black (not American)	6
European-American	5
Hispanic (not American)	2
Hispanic-American	4
Multiracial	2
Other	5
Gender	
Female	30
Male	23
Other	1

Age

With respect to age, the sample was consistent with the sampling frame, and participants ranged in age from 18 to 57. The mean age for participants in this study was 24.83, and the mean age for participants in the sample frame is 25.59. The demographic characteristics are compared to the population of interest, all college students. With respect to age, the sample is also consistent with the population of interest. Although one-third of college students is age 25 or older (National Student Clearing House Research Center, 2012), college students aged 18 to 24 outnumber students age 25 and older in the population of interest (National Student Clearing House Research Center, 2012) and in the study sample: 38 traditional age students versus 16 older students.

Gender

With respect to gender, the sample was not proportional to participants in the sampling frame. At the college from which the sample was drawn, men outnumber women, but in this study men outnumbered women. With respect to gender, the sample is not reflective of the population of interest. In the population of interest, men are in the minority and women outnumber men (U.S. Department of Education, 2013), but in this study men (n = 30) outnumbered women (n = 23). This difference did not seem to be a reason to halt the data analysis, however.

Ethnicity

With respect to ethnicity, the sample was not proportional to participants in the sampling frame. In the sampling frame as well as the study sample, African-Americans comprised the largest non-white single racial/ethnic group. The number of Hispanic students in the study sample is proportionally larger than in the sampling frame. The number of American Indian, Asian, European-American, and multiracial Americans is proportionally larger in the sampling frame than in the study sample for these groups (See Table 2).

With respect to ethnicity, the sample was not proportional to the population of interest, but did seem consistent with overall trends. For college students in the U.S., African-Americans are the largest single racial/ethnic group (U.S. Department of Education, 2013) and African-Americans were the largest racial/ethnic group in the study sample. The percentage of Hispanic students (14%) in the population of interest is greater than the percentage of Hispanic students in the study sample. In contrast, the percentage of Asian students (6%) in the population of interest is smaller than the percentage of Asian students in the study sample. The percentage of American Indian (0.9%), and European-Americans (61%) in the population of interest is smaller than in the study sample (See Table 2).

Statistical Conclusion Validity

Evaluation of Hotelling's T^2 Assumptions

Independence. Random assignment of each participant to the digital game group or print-based group was conducted. The procedures for this study were designed to ensure that participants for both groups were independently sampled to ensure that this assumption is not violated. The assumption of independence was met.

Multivariate normality. Skewness and kurtosis were computed (See Table 3) to determine whether the shape of the distributions of the dependent variables were within the normal range. For skewness and kurtosis, values less than 2 or greater than -2 are within the normal range (Tagler, 2007). The obtained values for skewness for the distribution of mental effort scores was .09 for all participants. The obtained values for kurtosis for the distribution of mental effort scores was 2.99 for all participants. For the distribution of time-on-task scores, the obtained skewness was -.07 for all participants. The obtained kurtosis for the time-on-task variable was.1.74

Table 3

Mental Effort and Time on Task Statistics for All Participants

Variable	Mean	*SD*	Skewness	Kurtosis	*N*
Mental Effort	15.63	5.49	.09	2.99	54
Time on Task	67.94	36.97	-.07	1.74	54

The distribution of the scores for the dependent variable mental effort is within the normal range for skewness, but outside of the normal range for kurtosis. The distribution of the scores for the dependent variable time on task is within the normal range for skewness and kurtosis. None of the scores was significantly skewed. The time on task scores are within the normal range for kurtosis and the mental effort scores are significantly kurtotic. However, Hotelling's T^2 test is not generally sensitive to violations of the normality assumption (Wiesner, 2006).

Homoscedasticity. To determine whether the dependent variables were homoscedastic or heteroscedastic, a scatterplot was created. The scatterplot for the dependent variables, mental effort and time on task was elliptical in shape (See Figure 4), which indicates that a small level of homoscedsasticity may have been present (Bordens & Abott, 1991). Because the Hotelling's technique is relatively robust and can handle potential outliers in variables with restricted ranges, the decision was made to not exclude outliers.

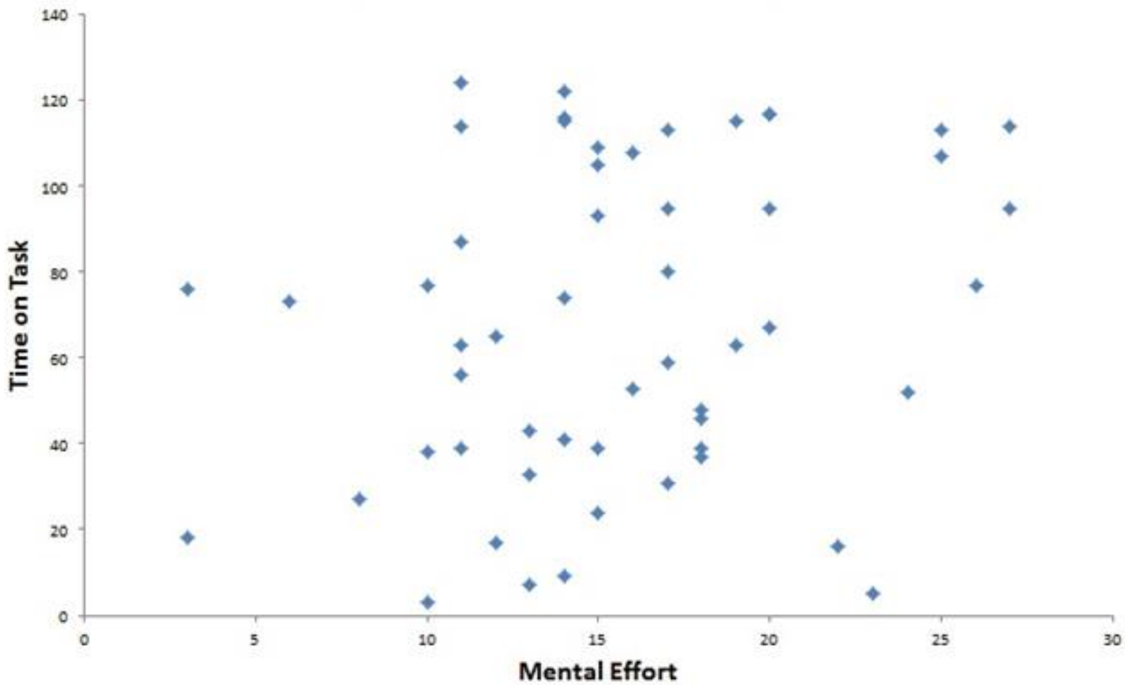

Figure 4. Scatterplot of dependent variables.

Reliability Analysis

Cronbach's alpha was used to determine the internal consistency of MES scores from this study's participants. A reliability check was conducted to address any potential problems with measurement precision for MES scores, due to unforeseen sources of error. An alpha should at minimum be .60 to be acceptable (Gliner, Morgan, & Leech, Nunnally as Cited in Taris, 2008; Yu & Mensah, 2011), although it is preferred that alpha exceed .70 (Nunnally as Cited in Taris, 2008; Yockey, 2011; Yu & Mensah, 2011). The alpha for MES scores was .76, which exceeded the .70 standard.

Inferential Statistics

The Hoteling's T^2 indicated that there was an overall statistically significant difference between the digital game-based textbook group and participants in the traditional print-based textbook group, $T^2(2, 52) = 25.11$, $p < .001$, $D^2=1.86$. Post hoc analyses of the means (see Table 4) with univariate *t* tests were conducted to determine whether the overall significant difference was true for each dependent variable.

Table 4

Mental Effort and Time on Task by Intervention Group

	Mental effort				Time on task				
Group	Mean	*SD*	Min	Max	Mean	*SD*	Min	Max	*N*
Digital game	17.33	5.95	3	27	87.66	33.22	5	124	27
Print-based	13.93	4.46	3	27	48.22	29.57	3	115	27

To control for Type I error resulting from post hoc multiple comparisons, a Bonferroni correction (Field, 2009) was applied. The adjustment was used with the alpha level of .01, which was divided by the number of post hoc tests resulting in an alpha of .005 being used to assess each individual *t*-test. The results of the post hoc analyses show that a significant difference between the digital game-based textbook group and print-based textbook group exists for the dependent variable time on task ($t = 4.61$, $p < .001$). Time on task was significantly higher for the digital game-group. The results of the post hoc analyses showed no statistically significant difference, based on the conservative criterion, exists between the digital game-based textbook group and print-based textbook group for the dependent variable mental effort ($t = 2.30$, $p = .021$). The trend was toward a positive impact, however, and a larger sample might have demonstrated the expected outcome.

Summary

The goal of this study was to determine the effect of undergraduate textbook format on academic performance. I aimed to determine whether a significant difference in mental effort and time on task exists for college students who used a digital game-based textbook and college students who used a traditional print-based textbook. Fifty-four participants were randomly assigned to the digital game-based textbook group or traditional print-based textbook group and completed a textbook activity session. The result of the reliability analysis is a Cronbach's alpha of .76, which indicates that the MES was a reliable measure of mental effort for participants in this study. After determining that the assumptions for the Hotelling's T^2 inferential statistical test were met, data analyses were conducted. The results of the Hoteling's T^2 indicate that there was an overall significant difference in the mental effort and time on task of participants in the digital game-based textbook group and participants in the traditional print-based textbook group, $T^2(2, 52) = 25.11$, $p < .001$. The multivariate measure of effect size, Mahalanobis distance was computed. The effect size, $D^2 =1.86$, obtained for this study is considered a large effect size. The reliability of the mental effort measure for use with this study's sample was assessed via reliability analysis. These results are interpreted in the next chapter. In the next chapter, the implications for social change and recommendations for future research are presented.

Chapter 5: Discussion

Introduction

In this study, I examined the efficacy of using a digital game-based textbook as an alternative to the traditional print-based textbook for increasing mental effort and time on task with college textbook material. The purpose of this study was to determine whether there was a significant difference in engagement as indicated by mental effort and time on task, based on the textbook format. I expected that textbook type (digital game-based or traditional print-based) would have a significant impact on mental effort and time on task. This study was quantitative in nature and used a causal-comparative design. The sample for this study was comprised of 54 matriculated undergraduate students at a community college in the Washington D. C. metropolitan area. This chapter includes a discussion of the study's results. This chapter has been organized into these major sections: (a) Introduction, (b) Interpretation of the Findings, (c) Limitations of the Study Change, (d) Recommendations for Further Research, (e) Implications for Social Change and (f) Conclusion.

Interpretation of the Findings

Hotelling's T^2 test was the primary statistical test used for this study. It was selected because the multivariate approach is advantageous when dependent variables are regarded as a set (Everitt, 2001). The dependent variables of mental effort and time on task were regarded as a set, because they are conceptualized as a set in Astin's (1994) student involvement theory. The first premise of student involvement is that there is a need for time on task and mental effort to occur simultaneously and not independently of one another. The results of the Hotelling's T^2 indicated that there was an overall significant difference in the mental effort and time on task of participants in the digital game-based textbook group and participants in the traditional print-based textbook group, $T^2(2, 52) = 25.11$, $p < .001$. The multivariate measure of effect size ($D^2 = 1.86$) obtained for this study is considered a large effect size.

The results of the post hoc analyses showed a significant difference between the digital game-based textbook group and print-based textbook group existed for one of the dependent variables, time on task ($t = 4.61$, $p < .001$), but not the other, mental effort ($t = 2.30$, $p = .021$). However, mental effort was greater for the digital game-based group ($M = 17.33$) than the print-based group ($M = 13.93$). The results of a post-hoc power analysis suggest that a larger sample size was likely needed to detect significance. Power of magnitude .80 at the .01 level was needed to detect an existing significant difference between groups, but the statistical power achieved was only .50. The leptokurtotic nature of the distribution may have also impacted the results. Still, the direction of the effect was positive.

The research findings related to time on task were similar to several previous studies. The findings matched those of Sward et al. (2008) on digital game-based learning, who found that participants in a web-based gaming group spent significantly more time on task than participants in a web-based flash-card group. The results of this study are also similar to the results of Adams et al. (2012), who found that a narrative game-based group of college students spent more time on task when using a modified version of the popular Half-Life 3D digital game than a slide-show presentation of the same content. The time on task results for this study are also similar to the results of a previous study (Um et al., 2012) that used an interactive multimedia format and resulted in participants in the positive emotional design group spending more time on task than participants in a neutral group when engaged with academic content. Unlike the Sward, et al., 2008 and the Um et al., 2012 studies, however, this study did not find a significant difference in the amount of mental effort of participants in the experimental and comparison group, although mental effort was greater for the digital game-based group (M = 17.33) than the traditional print-based textbook comparison group (M = 13.93).

Limitations of the Study

There are several limitations for this study. The scope of this study was limited to the conceptual frameworks of mental effort and time on task, the key concepts discussed in the first three premises of Astin's (1994) student involvement theory. This focus was chosen,because these constructs are relevant to the research question and may be operationalized using valid and reliable measures. In addition, a convenience sample was used in this study. Because a convenience sample is a non-probability sampling design, scientific inferences about what exists in the population of interest cannot be made. The results should be interpreted with caution. This shortcoming was largely unavoidable, due to the nature of the study. Using a non-probability sampling design was largely unavoidable, because it was not feasible to generate a complete sample frame for the population of interest, all adult degree-seeking undergraduate college students, because I did not have the ability to gain access to the names or contact information of all adult degree-seeking undergraduate college students. Probability sampling strategies (e.g., cluster, simple random, stratified, systematic) require compiling a sampling frame and selecting sample elements based on probability (Schutt, 2012).

The use of a self-report measure of mental effort prevented a determination of whether or not research participants honestly reported their mental effort. However, the nature of the measures did not suggest a need of the participants to lie or give socially desirable responses. A final limitation of this study is that only a single textbook chapter was used that focuses on one subject (research methods). This focus means that scientific inferences about the efficacy of the digital game-based textbook with other subject areas are outside of the scope of this study.

Recommendations for Further Research

During data collection, it was observed that some participants in both the digital game-based textbook and traditional print-based textbook voluntarily elected to take notes on the academic content that was presented throughout the textbook activity session. Although note taking was outside the scope of this study, future studies could examine whether or not a significant difference in amount and quality of note taking exists for students using a digital game-based textbook and student using a print-based textbook.

Future studies should extend this research by also including learning as a dependent variable. Astin's (1994) student involvement theory was used as the theoretical framework for this study, and learning is the outcome variable in Astin's theory, which postulates that increased mental effort and time on task leads to increased learning (Astin, 1985, 1999). Mastery learning was strategically designed into the structure of the digital game-based textbook through not allowing participants to proceed to the next section without first mastering the current section. The extent to which participants engage in mastery learning could be considered in future studies using a learning assessment instrument.

Future research should include research studies that use digital games in varied formats. There are a variety of popular digital game genres (Baek & Heo, 2010). This study used a live-action sequence game, which is also known as a twitch game in the entertainment market. Twitch games involve the player's thumbs moving at a very fast pace (Prensky, 2001). Additional research is needed to determine if digital game-based textbooks grounded in other popular digital game genres are also effective for increasing student engagement.

Implications for Social Change

As mentioned earlier in this dissertation, it is likely that no institution in the United States has had more impact on the quality of people's lives than higher education (Baum & Ma, 2007). This study adds knowledge about the efficacy of alternatives to textbooks for out-of-class studying. It is hoped that the results of this research can be used to contribute to the improvement of the academic experience of college students seeking higher education and thus improve society.

This study provides college educators with compelling evidence that the digital game-based textbook is a viable alternative textbook format to the traditional print based-textbook format. The results of this study provide evidence that a digital game-based textbook can increase student involvement with the course material. These results suggest that a digital game-based textbook could help students to learn college course material and improve the academic performance of students in college courses.

The results of this study show that the digital game-based textbook is an educational technology instructional tool that effectively engages students in college course content outside of the structured environment. The digital game-based textbook effectively engages students of the college classroom as a result of significantly increased time on task and comparable exertion of mental effort relative to that exerted in response to a traditional print-based textbook. Because this educational technology instructional tool is primarily an entertaining game and secondarily a textbook, it is believed that the digital game-based textbook is more likely to compete successfully with the compelling demands that many college students face outside of the classroom than the traditional print-based textbook.

Conclusion

Although previous studies have been conducted on educational games and their relation to student learning (Adams et al., 2012; Alsagoff, 2005; Baek & Heo, 2010; Kiili, 2005, Pivec, 2009), this is the first study to address the gap in the literature on digital game-based learning theory and its relation to student involvement with college course content. This study focused on the identification and testing of a digital game-based textbook that successfully engaged students by eliciting their mental effort at levels at least comparable to the mental effort used with a traditional print-based textbook and eliciting greater time on task relative to time spent with a traditional print-based textbook with college-textbook content outside of class. These results are important, because involvement with college course material outside of the classroom is a requirement for success in many face-to-face college courses (Kuh et al., 2006).

In his student involvement theory, Astin (1985, 1999) discussed the critical role that engagement has in student failure or success in college (DeAngelo et al., 2011; Sharkness & DeAngelo, 2011). It is hoped that the results of this research will be used to contribute to the improvement of the academic experience of college students in higher education and thus improve society. The results of this study provide compelling evidence that the digital game-based textbook is a viable alternative textbook format to the traditional print based-textbook format. This research lays the ground work for future research on digital game-based textbooks and learning.

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Appendix A: Digital Game Characteristics

PRENSKY'S CHARACTERISTICS OF DIGITAL GAME-BASED LEARNING	RATIONALE
INCORPORATION OF GOALS AND OBJECTIVES	The videogame textbook incorporates objectives by listing the learning objectives at the beginning of each game level. The use of goals is achieved as a result of successful advancement in the game to the final level requiring the player to meet each level's objectives
REPRESENTATION OR STORY	The videogame textbook embeds the learning material into the storyline of the game. The storyline of the videogame textbook involves the main character striving to same Global Tech University from annihilation while preparing for his College final exams.
RULES	The videogame textbook incorporates rules by requiring the player to meet learning and level objectives. Specifically, the key rule of the game is that player may not advance to the next level until the player has demonstrated knowledge of the current level's content.
INTERACTION	The videogame textbook allows the player to interact with a 3-D world as an avatar looking for hidden clues about curriculum content that will allow the player to successfully answer the questions presented at the end of each level in order to advance to the next level.
OUTCOMES AND FEEDBACK	Outcomes are assessed from the players attempt to correctly answer content related questions presented at the end of each level. A player must correctly answer questions. Feedback is given, because 100% correct answers result in the access code allowing the player to advance. Incorrect answers to content questions result in an incorrect prompt and note that level must be repeated.
CHALLENGE IN FORM OF COMPETITION, CONFLICT OR OPPOSITION	Conflict and opposition are utilized in the videogame textbook. Conflict is utilized through artificial intelligence scripts, which allow Objects in the 3D world to impede progress.

Appendix B: Informed Consent Form

INFORMED CONSENT FORM

College Student Textbook Study

Background Information:
You have been invited to participate in a study. The purpose of this study is to learn about how college students interact with college textbooks. This study is being conducted by Antonio Thomas, a doctoral student, at Walden University.

Inclusion Criteria for Study Participation:
1. Being currently enrolled in college
2. Being within the first 2 years of undergraduate study (60 credits or less)
3. Being at least 18 years of age

Procedures:
If you agree to participate in this study, you will be asked to:
- Complete a learning activity
- Fill out a questionnaire
- Receive compensation for your participation

This study does not have a minimum amount of time for participation. However, I estimate that your participation will take a total of 30 minutes from start to finish. This study has been designed so that you may go at your own pace, which means that you may spend more or less time than 30 minutes.

Voluntary Nature of the Study:
Your participation in this study is strictly voluntary. Your decision whether or not to participate will not affect your current or future relations with the community college. If you initially decide to participate, you are still free to withdraw from this research study at any time without affecting those relationships.

Risks and Benefits of Being in the Study:
There are minimal risks associated with participating in this study. No conflicts of interest are associated with this study. The expected benefits of participating in this study include increased knowledge of research methods. In the event you experience stress or anxiety during your participation in the study, you may terminate your participation at any time. You may refuse to answer any questions you consider invasive or stressful.

Compensation:
There will be a $10 gift certificate for your participation in this study.

Confidentiality:
The records of this study will be kept private. In any report of this study that might be published, the researcher will not include any information that will make it possible to identify you. Research records will be kept in a locked file, and only the researcher will have access to the records.

Contacts and Questions:
The researcher's email address is Antonio.Thomas@WaldenU.edu. If you have questions about your rights as a participant, you may contact the Walden representative who can discuss this with you. The Walden representative may be contacted at 1-800-925-3368, extension *3121210*, if you have any questions. Walden University's approval number for this study is **03-10-14-0104715**.

You will receive a copy of this form from the researcher for your records.

Statement of Consent

_____ **(initials)** I have read the above information. I DO consent to participate in this study.

Today's Date:____________

Printed Name of Participant

____

Participant Signature

____

This has been approved by the Institutional Review Board of WALDEN UNIVERSITY as acceptable documentation of the informed consent process and is valid for one year after the stamped date.
03-10-14-0104715

Appendix C: Eligibility Screener

The following questions are presented to determine whether or not you meet the criteria for participation in this study. Please answer each of the following questions. If you need assistance, please let the researcher know. After you complete this screener, the researcher will verify your information in the college information system.

1. What age category do you fall within?
   a. Over 18.
   b. Under 18. SKIP TO ITEM 5.

2. Are you currently enrolled in college as a degree seeking student?
   a. Yes.
   b. No. SKIP TO ITEM 5

3. How many college credits have you completed?
   a. 60 college credits or less.
   b. More than 60 college credits. SKIP TO ITEM 5.

4. ___Place a check here. You are eligible to participate in this study! Please see the researcher to get started.

5. ___Place a check here. You meet one or more of the exclusion criteria for this study. That means that you are not eligible to participate in this study. Thank you for time.

Appendix D: Standard Activity Session Protocols

1. The researcher will conduct the causal comparative research study across multiple sessions during a one to two month period. Each activity session will be conducted in the reserved computer lab of a local college or local public library.

2. The researcher will conduct an informed consent procedure when participants arrive at an activity session. The researcher will provide each participant with a written informed consent document (see Appendix B).

3. The researcher will give an eligibility screener to each prospective research participant (see Appendix C). The researcher will obtain a signed informed consent document from each research participant.

4. The researcher will assign participants to either the first group (print-based textbook group) or second group (digital game-based textbook group).

5. The researcher will follow a standard activity session protocol (see Appendix E). Participants will not be limited to a minimum period of time for study participation. I expect that the majority of participants will complete the study in less than one hour, because participant completion of the measures after the participant of textbook content will take approximately three minutes to complete and participant review of textbook content will take 20 to 25 minutes to complete. This will allow for sufficient time, because this study uses two groups, including a comparison group, which will allow differences between these groups to be measured.

6. The researcher will administer the Mental Effort Scale and demographic survey after the participant has completed the activity session.

7. The researcher will thank study participants for their research participation. After the activity session has concluded, participants who were not in the digital game-based group will be given the opportunity to view and engage in this activity, as suggested by Creswell (2009).

Appendix E: Instructions for Textbook Activity Session

Thank you for your voluntary participation in this activity session. The purpose of this activity session is to learn about student engagement with textbooks. In a few moments, you will be given an opportunity to engage with a textbook. You are being asked to interact with the textbook as you normally would if you were studying at home or at your local library. You should interact with the textbook for as long or short as you like, in order for you to learn the information that is presented. However, the amount of time that you spend with this textbook is up to you. When you are finished, please let the researcher know. Thank you for your participation.

Appendix F: Mental Effort Scale

1. In solving or studying the preceding lesson I invested:

1	2	3	4	5	6	7	8	9
Very Very Low Mental Effort	Very Low Mental Effort	Low Mental Effort	Rather Low Mental Effort	Neither Low Nor High Mental Effort	Rather High Mental Effort	High Mental Effort	Very High Mental Effort	Very Very High Mental Effort

2. I experienced the foregoing instruction as:

1	2	3	4	5	6	7	8	9
Very Very Low Mental Effort	Very Low Mental Effort	Low Mental Effort	Rather Low Mental Effort	Neither Low Nor High Mental Effort	Rather High Mental Effort	High Mental Effort	Very High Mental Effort	Very Very High Mental Effort

3. How easy or difficult was this instruction to understand:

1	2	3	4	5	6	7	8	9
Very Very Low Mental Effort	Very Low Mental Effort	Low Mental Effort	Rather Low Mental Effort	Neither Low Nor High Mental Effort	Rather High Mental Effort	High Mental Effort	Very High Mental Effort	Very Very High Mental Effort

Appendix G: Demographic Questionnaire

1. Please select the age that you are today.

   ➔Pull down menu with numbers 1-100

2. Which of the following reflects your sex/gender?

   1. Male
   2. Female

3. About your college status, which of the following are you?

   1. Freshman
   2. Sophomore
   3. Junior
   4. Senior

5. On average, how many hours of videogames do you play each day?

   ➔Pull down menu with numbers 0-24

6. On average, how many hours of videogames do you play each week?

   ➔Pull down menu with numbers 0-100

7. What is your race/ethnic identification?

   1. Asian-American
   2. Asian, not American
   3. Black or African-American
   4. Black, not American
   5. European-American
   6. European, not American
   7. Hispanic-American or Latino/a-American
   8. Hispanic or Latino, not American
   9. Multiracial
   10. Native-American
   11. Other

Appendix H: Permission to Use Print-Based Textbook Content

Reply | Reply All | Forward | Delete | Move to Folder | Add to

Subject : Re: Request for Permission to Use Textbook
Date : Thu, Jul 25, 2013 01:02 PM CDT
From : Washington Longfellow <washingtonlongfellowpress@gmail.com>
To : Antonio Thomas <antonio.thomas@waldenu.edu>

Dear Antonio,

You have my permission and permission of Pillars Academic Publishing, a division of Washington Longfellow Press, to use the content of my textbook, Social Science Research Methods, for use in your dissertation study at Walden University. I look forward to receiving the results of your study.

Good luck with your dissertation!

Dr. Gibbs

On Thu, Jul 25, 2013 at 12:57 PM, Antonio Thomas <antonio.thomas@waldenu.edu> wrote:

> Dear Dr. Gibbs:
>
> I hope this finds you well. As we discussed,I am writing to request permission to use the Social Science Research Methods textbook published by Pillars Academic Publishing, a division of Washington Longfellow Press.
>
> I am a Ph.D. student in education at Walden University and am interested in using the textbook content for my dissertation study on student involvement theory and digital game-based learning. Specifically, I would like to use the textbook content in the existing print-based format and in a digital-game format. The digital game format of the textbook be used exclusively for dissertation study purposes. The purpose of my dissertation study is to determine whether textbook type has an impact on the mental effort and time on task of college students.
>
> I am excited about the possibility of being able to use the textbook and would provide you with a copy of the results of the research. Thank you for your consideration.
>
> Sincerely,
> Antonio

Appendix I: Participant Recruitment Flyer

RESEARCH OPPORTUNITY

- Be in a study for college students
- Study goes at the pace of the student
- Expected time commitment is 30 minutes or less
- Compensation is $10.00 gift card

The purpose of this study is to learn about how students interact with college materials. A doctoral student at Walden University is conducting this study. This study is approved by the Montgomery College Institutional Review Board and the Walden Institutional Review Board, IRB# 03-10-14-0104715.

Participants Must Meet These Inclusion Criteria

1. currently enrolled in college as a degree seeking student
2. within the first 2 years of undergraduate study (60 credits or less)
3. at least 18 years of age

Participation in this study is voluntary and confidential. To participate in this study, contact the researcher at Antonio.Thomas@WaldenU.edu or 202-503- 9086 and say you are calling about “The College Student Research Study”.

Appendix J: Activity Session Content for Print-Based Textbook

COMPLETE CHAPTER CONTENT

Appendix K: Activity Session Content for Digital Game-Based Textbook

Content Area	**PRINT-BASED TEXTBOOK CONTENT** Print-based Textbook Group	**DIGITAL-GAME TEXTBOOK CONTENT** Digital-game Textbook Group
INTRODUCTION TO SOCIAL SCIENCE RESEARCH	✓	✓
ETHICS FOR CONDUCTING RESEARCH	✓	✓
POPULAR RESEARCH DESIGNS FOR CONDUCTING RESEARCH	✓	✓
STATISTICS FOR ANALYZING RESEARCH DATA	✓	✓
SUMMARY	✓	✓
CHAPTER QUESTIONS	✓	✓

Appendix L: Permission to Use Mental Effort Scale

Subject : **Re: Request for Permission to Use the Paas Mental Effort Scale**
Date : Tue, Nov 20, 2012 03:22 AM CST
From : Fred Paas <paas@fsw.eur.nl>
To : Antonio Thomas <antonio.thomas@waldenu.edu>
Attachment : vangogpaaseducationalpsychologist2008.pdf
PaasTuovMerDar.pdf
Educational_Psychologist_Paas1.pdf
mental_effort_rating_scale.pdf

Dear Antonio,

I just received your e-mail, because you sent it to three either old or not used e-mail addresses.

Sure you can use the scale. I have attached it and also some articles that might be relevant for your research (one is on measuring task involvement based on the scale). The only thing I ask from you is to cite the appropriate articles if you publi your work.

Good luck with your studies and don't hesitate to ask me if you have any other questions.

Best wishes,

Fred

FRED PAAS | Professor of Educational Psychology Institute of Psychology ERASMUS UNIVERSITY ROTTERDAMP.O. B 1738 | 3000 DR Rotterdam | Netherlands

CURRICULUM VITAE

ANTONIO THOMAS

EDUCATION

- Doctor of Philosophy, Educational Technology, Walden University, 2014
- Master of Arts Studies, Communications, Univ. of Oklahoma, 2010 – 2012
- Master of Arts, Interdisciplinary Studies, Arizona State University, 2003
- Bachelor of Arts, Political Science, Arizona State University, 2005
- Bachelor of Science, Administration of Justice, Arizona State University, 2001

TEACHING EXPERIENCE

- ***University of Baltimore***, Baltimore, MD, Adjunct Faculty, 2014 – present
- ***Montgomery College***, Rockville, MD, Adjunct Faculty, 2006 – present
- ***DeVry University***, Crystal City, VA, Adjunct Faculty, 2008 – 2011
- ***United States Air Force,*** Commando Warrior Air Base Ground Defense School, Instructor, 1992-1993

UNDERGRADUATE COURSES TAUGHT

- Career Development
- College Success
- Critical Thinking
- First-Year Experience
- Games for Learning
- Gaming for Level Design & Modules
- History of Video Games
- Intro. to Gaming & Simulation
- Intro. to Human Communication
- Principles of Speech