Digital Game-Based Textbook vs. Traditional Print-Based Textbook: The Effect of Textbook Format on College Students' Engagement with Textbook Content outside of the Classroom

Antonio Lamar THOMAS
Montgomery College, UNITED STATES
Antonio.Tango.Thomas@gmail.com

ABSTRACT
The relatively little amount of time that some college students spend reading their textbooks outside of the classroom presents a significant threat to their academic success. Using Prenksy's (2001) digital game-based learning (DGBL) principles and Astin's student involvement theory as frameworks, the purpose of this true experiment was to determine whether a significant difference in engagement, as indicated by mental effort and time on task, existed between college students who used a digital game-based textbook and students who used a traditional print-based textbook. A customizable digital game-based textbook designed using DGBL principles in a popular gaming genre embedded with textbook content identical to content in a traditional print-based textbook was used. Fifty-four undergraduate college students were randomly assigned to experimental and control groups. The results showed a statistically significant, Hotelling's T^2 (2,52)=25.11, p<.001, D^2=1.86 difference in engagement between participants in the experimental and control groups and a large overall effect size. Post hoc analyses indicated the digital game-based textbook group, exerted significantly greater mental effort (t = 2.38, p<.001, d=.65) and spent significantly more time on task (t = 4.61, p < .025, d=1.25) than the traditional print-based textbook group.

Keywords: digital games, game-based learning, mental effort, student engagement

INTRODUCTION

Although a number of students are not compelled to engage in reading the college textbook outside of the classroom (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 for entertainment purposes and simultaneously increases student engagement with academic content outside of the classroom, then there would be a viable learning tool that may be effective for learning.

In the educational environment, digital games, as a learning tool, have gained very little headway. 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 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 digital game-based approach truly engages learners in the process; information that might compel faculty to reconsider it as an option. 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 (1999), "The theory of student involvement argues that for 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 (1999) 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.

Research has demonstrated (Stratton, 2011), many students are not engaging sufficiently, and in some cases not engaging at all with 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 primary learning resource that students are expected to use outside of the classroom (Lord, 2008). If traditional textbooks are not

Copyright © The Turkish Online Journal of Educational Technology

eliciting mental effort and time on task, educators should be focusing on methodologies that do. One such methodology may be digital game-based learning. Digital game-based learning (DGBL) theory emerged as the result of the contributions of several scholars focused on this area (Dziorny, 2005), and in particular Prensky (2001). Prensky's (2001) book, Digital Game-Based Learning, introduced the concept of DGBL. 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). According to Prensky, DGBL involves an educational game 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. Prensky (2001) noted that there are six characteristics of compelling digital games: a) incorporation of goals and objectives, b) representation/story, c) rules, d) interaction, e) outcomes and feedback, and f) challenge in the form of competition, conflict, or opposition.

Digital game-based learning theory served as the theoretical framework for using a customizable digital game-based textbook, which was a customizable digital-game in a popular gaming genre designed using DGBL principles. Astin's (1999) student involvement theory served as the guiding theoretical framework for understanding student engagement and developing a hypothesis about students' mental effort and time on task. The purpose of this study was to determine whether there was a significant difference in student engagement with textbook content as indicated by mental effort and time on task, based on the textbook format. In this study, 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 content was examined. For a sample of undergraduate college students, are there significant differences in engagement as indicated by mental effort and time on task, based on textbook format (traditional or digital game-based)? It was hypothesized that there would be a significant difference in engagement as indicated by mental effort and time on task with students using a digital game-based textbook exerting significantly more mental effort and time on task than students using a traditional print-based textbook.

METHOD

A convenience sample of 54 participants ranging in age from 18 to 57 was used. The mean age for participants in this study was 24.83. Most participants were between the ages of 18 to 24 (n=38). Non-traditional aged students included students between the ages of 25 and 34 (n=9), as well as students between the ages of 35 and 60 (n=7). Participants were degree-seeking college students at a public community college. Twenty-six of 54 students were first-year/freshman college students. Twenty-eight were second-year/sophomore college students.

An ethnically diverse sample was obtained including African-Americans (n=24), Blacks (not American) (n=6), European-Americans (n=5), other (n=5), Asian-Americans (n=4), Hispanic Americans (n=4), Asians (not American) (n=2), Hispanics (not American) (n=2), and multiracial students (n=2). Participants identified as female (n = 30), male (n = 23), and other (n=1).

Materials

Digital game-based textbook, a customizable PC-based digital game (Thomas, 2017) designed using DGBL principles in a popular gaming genre embedded with textbook content identical to content in a traditional print-based textbook was used. The digital game is a live-action sequence game with nine levels. The live action sequence game, a twitch game, included 100% of the content from the Introduction to Social Science Research chapter in the *Social Science Research Methods* textbook.

Traditional print-based textbook, one chapter, Introduction to Social Science Research, from *Social Science Research Methods* (Gibbs, 2013) was used. The print-based textbook chapter (see Appendix A) was 8.5 x 11 in (215.9 x 279.4 mm) in dimension and included 37 pages with four major content areas. In addition to four sections and a summary, the textbook chapter included chapter definitions and chapter questions. The chapter questions section includes 32 multiple-choice questions with eight questions for each major content area.

Instrumentation

Mental effort scale**,** the Mental Effort Scale or MES (Paas, 1992), the most widely used measure in this area of research (Paas, Tuovinen, Tabbers, & Van Gerven, 2003) was used due to its psychometric soundness (Paas, 1992; Paas & Van Merrienboer, 1994; Van Gog, Paas, & Van Merrienboer, 2008; Kester, Kirschner, & Van Merrienboer, as cited in Van Gog et al., 2008) and ease of use. The MES utilizes five 9-point Likert-type items. Scores are computed by summing participant responses for each item on the measure, with higher scores reflecting greater mental effort expenditure and lower score reflecting lower mental effort expenditure (Paas & Van Merrienboer, 1994).

Copyright © The Turkish Online Journal of Educational Technology

Stopwatch, 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. Questionnaire, a brief six-item questionnaire that captured demographic data on participant characteristics was used. The questionnaire content includes questions about age, gender, race/ethnicity, college level, and college work completed. Screener, an eligibility screener containing 5 questions was used to exclude any prospective participant who was under 18, not enrolled as a degree-seeking college student, or beyond the second year of college.

Procedure

Setting, the research study was conducted in a controlled setting. A computer lab with individual workstations on a college campus was reserved for multiple dates across a two-month time period. Each computer lab used for textbook activity sessions had individual workstations labeled with ID numbers.

Random assignment, a strategy of random assignment without replacement was used to assure an equal number of participants in both groups. Twenty-seven slips with the name dgbg (digital game-based textbook group) and 27 slips with the name pbtg (print-based textbook group) were placed in small sealed envelopes. Fifty-four participants were randomly assigned to the digital game-based textbook group or traditional print-based textbook group. Each participant drew an envelope on arrival, thus assuring random assignment to conditions of the independent variable.

Textbook activity sessions, after participants were seated at an individual workstation, participants completed an online informed consent process. Upon completion of the informed consent process, participants were instructed to minimize the online informed consent form. Next, participants were given written instructions, which marked the beginning of the textbook activity session. The standard activity session protocol was followed. There was no minimum period of time for the textbook activity session. Participants were limited to a maximum period of time for study participation, which was 2 hours. 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.

Recording textbook activity sessions, for all textbook activity sessions, digital game-based textbook and print-based textbook, screen recording was conducted. 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 assessed by viewing the recording after all data was collected.

Protection of participants, the four primary areas of ethical concern in social research were addressed. In this study 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. Approval from the related higher education institutions' Institutional Review Boards was obtained, prior to data collection. No participants from vulnerable populations were used 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. There were no reports of adverse effects from participation in this study.

Research participation incentive, each participant received a $10.00 gift card as an incentive for research participation.

RESULTS

The results of a Hotelling's T^2 test indicated that there was an overall statistically significant difference (see Tables 1 and 2) 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, $T^2(2, 52) = 25.11$, $p < .001$, $D^2=1.86$.

Table 1: Hotelling's T^2 for mental effort and time on task

Dependent Variables	T^2	DF1	DF2	p value	D^2
Mental Effort and Time on Task	25.11	2	52	.00	1.86

The multivariate measure of effect size, Mahalanobis distance, D^2, was computed for overall effect size. A large effect size, D^2 =1.86, was found. Like Cohen's *d*, recommendations for small, moderate, and large effect size indices have been provided (Ferron, Hess, Hogarty, & Kromrey 2004; Stevens, 1980; Stevens 2004), with .25, .64, and > 1.0 representing small, moderate, and large effect sizes respectively (Stevens, 1980; Stevens, 2002).

Copyright © The Turkish Online Journal of Educational Technology

Post hoc analyses of the means (see Table 2) with univariate *t* tests (see Table 3) were conducted to determine whether the overall significant difference was true for both dependent variables, mental effort and time on task. 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 .05, which was divided by the number of post hoc tests resulting in an alpha of .025 being used to assess each individual *t*-test.

Table 2: 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

The results of the post hoc analyses demonstrated a statistically significant difference exists between the digital game-based textbook group and print-based textbook group for the dependent variable mental effort (t = 2.38, p< .025). A medium effect size, d=.65, was found. Mental effort was significantly higher for the digital game-based textbook group. The result of the reliability analysis yielded a Cronbach's alpha of .76, which indicates that the MES was a reliable measure of mental effort for participants in this study.

The results of the post hoc analyses (see Table 3) also showed 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). A very large effect size, d=1.25, was found. Time on task was significantly higher for the digital game-based textbook group.

Table 3: Post hoc tests and effect sizes for dependent variables

Variable	*t*	*p* value	Cohen's *d*
Mental Effort	2.38	.02	.65
Time on Task	4.61	.00	1.25

DISCUSSION

It is important for educators who select textbooks to know that college students exerted significantly more mental effort and time on task (p<.001) when using a digital game-based textbook designed using DGBL principles than when using a traditional textbook. Interestingly, a large overall effect size (D^2 =1.86) was found, although the statistical power achieved for this study was only .50. The medium effect size (t = 2.38, p<.025) found for mental effort is compelling, but the very large effect size (t = 4.61, p < .001, d=1.25) found for time on task is undeniably convincing evidence of the ability of the ability of a DGBL video game textbook to increase student engagement with academic content.

Like the Sward, Richardson, Kendrick, and Maloney (2008) and Um, Plass, Hayward, & Homer's (2012) studies, this study found a significant difference in the amount of mental effort of participants in the experimental and comparison group with mental effort exerted by students being significantly (p<.025) greater for the digital game-based group (M=17.33) than the traditional print-based textbook group (M=13.93). In contrast to students in the traditional print-based textbook group who spent an average of 48.22 minutes on the textbook activity session, students in the digital game-based textbook spent an average of 87.66 minutes.

The findings related to time on task match those of Sward et al. (2008), 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; Adams, Mayer, MacNamara, Koenig, and Wainess (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; and (Um et al., 2012), who found that participants in the positive emotional design group spent more time on task than participants in a neutral group when engaged with academic content presented in an interactive multimedia format.

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 (1985) student involvement theory and did not include learning as a dependent variable. 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. This shortcoming was largely unavoidable, due to the nature of the study.

Copyright © The Turkish Online Journal of Educational Technology

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 measure 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.

CONCLUSION

The results of this study show that a digital game-based textbook designed using DGBL principles in a popular gaming genre with fun and interactivity as key elements with embedded educational content, is a learning tool that caused students to exert significantly greater mental effort and spend significantly more time on task with textbook content outside of the classroom. The digital game-based textbook was a superior elicitor of mental effort and time on task, because instead of students spending time with a game inside of a learning environment, students were spending time with learning inside of a gaming environment. The live-action sequence game, the digital-based based textbook, was effective because the game integrates all six of Prensky's (2001) characteristics of compelling digital games: a) incorporation of goals and objectives, b) representation/story, c) rules, d) interaction, e) outcomes and feedback, and f) challenge. This study provides stakeholders in higher education with research that may lead to a viable alternative textbook format to the traditional print based-textbook format. It would be useful for textbook authors and publishers to focus textbook development efforts on innovative textbook design of digital game-based textbooks using DGBL principles.

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, as conceptualized by Astin (1985), with college course content using a digital-game designed using DGBL principles outside of the classroom. This study adds to our knowledge about the efficacy of alternatives to traditional print-based textbooks for student engagement in outside-of-class studying. This study provides robust evidence that a customizable digital game-based textbook designed using DGBL principles increases college student involvement with textbook content outside of the classroom, which suggests that it may also lead to better learning of college course material and ultimately better academic performance of students in college courses.

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 should examine whether or not a significant difference in amount and quality of note taking exists for students using a digital game-based textbook and students using a print-based textbook.

Future studies should also extend this research by including learning as a dependent variable. Astin's (1999) student involvement theory was used as the theoretical framework for this study, and learning is the outcome variable in Astin's (1985) theory, which postulates that increased mental effort and time on task leads to increased learning (Astin, 1985, 1999). Although learning was outside the scope of this study, 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.

Finally, it would be useful for researchers to conduct 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 with textbook content outside of the classroom.

Acknowledgments

This work is based on my dissertation completed at Walden University. Thank you to Drs. Timothy Powell and Daniel Salter, whose feedback and support were invaluable. I express gratitude to Dr. Nichole Thomas for her support. Also, I recognize and appreciate the support of Drs. Dave Harris and Dunn-Reynolds, Huong Nguyen, Tayib Salmi, and Jessica Kagan.

Copyright © The Turkish Online Journal of Educational Technology

REFERENCES

Adams, D. M., Mayer, R. E., MacNamara, A., Koenig, A., & Wainess, R. (2012). Narrative games for learning: Testing the discovery and narrative hypotheses. *Journal of Educational Psychology, 104*(1), 235-249. http://dx.doi.org/10.1037/a0025595

Alsagoff, Z. A. (2005). *The challenges and potential of educational gaming in higher education*. Paper presented at the Second International Conference on ELearning for Knowledge-Based Society, Bangkok, Thailand.

Arum, R., & Roska, J. (2011). *Academically adrift: Limited Learning on college campuses.* Chicago, IL: The University of Chicago Press.

Astin, A. W. (1985). *Achieving educational excellence.* San Francisco, CA: Jossey-Bass.

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518–529.

Baek, T. Y., & Heo, H. (2010). Research trends in game-based learning. *International Journal for Educational Media and Technology, 4*(1), 97-107.

Culver, T. F., & Morse, L. (2012). The impact of experience on college students' textbook reading practices. *Journal of College Literacy & Learning, 38*, 15- 24.

Dziorny, M. (2005). *Is digital game-based learning (dgl) situated learning?* Texas: University of North Texas.

Ferron, J., Hess, M., Hogarty, K., & Kromrey, J. (2004). *Interval estimates of multivariate effect sizes: Accuracy and precision under nonnormality and variance heterogeneity*. Paper presented at the Annual Conference of the AERA, San Diego, CA. retrieved from http://www.coedu.usf.edu/main/departments/me/documents/interval.pdf

Field, A., (2009). *Discovering statistics using SPSS.* (3rd ed.) Thousand Oaks, CA: Sage.

Gibbs, N. (2013). *Social science research.* Washington, DC: Pillars Academic Press.

Gros, B. (2007). Digital games in education: Design of games-based learning environments. *Journal of Research on Technology in Education, 40*(1), 23-38. http://dx.doi.org/10.1080/15391523.2007.10782494

Hirumi, A., Appelman, R., Rieber, L., & Van Eck, R. (2010). Preparing instructional designers for game-based learning, part 1: Game design as an instructional design process. *Tech Trends, 54*(3), 27–37.

Kiili, K. (2005). Content creation challenges and flow experience in educational games: The IT-emperor case. *Internet and Higher Education, 8,* 183-198.

Lord, T. (2008). "Darn it, Professor. Just tell us what we need to know to pass your course." *Journal of College Science Teaching*, *37*(3), 71-73.

Moshirnia, A. (2007). The educational potential of modified video games. *Issues in Informing Science and Informational Technology, 4,* 511-521.

Paas, F. G. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*(4), 429-434. http://dx.doi.org/10.1037/0022-0663.84.4.429

Paas, F. G., & Van Merrienboer, J. J. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A cognitive load approach. *Journal of Educational Psychology, 86*(1), 122-133.

Pivec, P. (2009). Game-based learning or game-based teaching? Retrieved from http://dera.ioe.ac.uk/1509/1/becta_2009_emergingtechnologies_games_report.pdf

Prensky, M. (2001). *Digital game-based learning.* New York, NY: McGraw-Hill.

Prensky, M. (2003). Digital game-based learning. *ACM Computers in Entertainment, 1*(1), 1-4. http://dx.doi.org/10.1145/950566.950596

Riegle, R. P. (2005). The future of online courses: How to win the marketing war. *Journal of College Teaching & Learning, 2*(3), 53-56. http://dx.doi.org/10.19030/tlc.v2i3.1786

Stevens, J. (1980). Power of the multivariate analysis of variance tests. *Psychological Bulletin, 88*(3), 728-737. http://dx.doi.org/10.1037/0033-2909.88.3.728

Stevens, J.P. (2002). *Applied multivariate statistics for the social sciences* (4th ed.). Mahwah, NJ: Erlbaum.

Stratton, G. (2011). Does increasing textbook portability increase reading rates or academic performance? *Inquiry*, *16*(1): 5–16.

Sward, K., Richardson, S., Kendrick, J., & Maloney, C. (2008). Use of a web-based game to teach pediatric content to medical students. Ambulatory Pediatrics*, 8(*6), 354-359. http://dx.doi.org/10.1016/j.ambp.2008.07.007

Thomas, A. L., & Thomas, N. G. (2017). *Improving the traditional textbook as a learning object using digital game-based learning principles.* Manuscript in preparation.

Um, E., Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. *Journal of Educational Psychology, 104*(2), 485-498. http://dx.doi.org/10.1037/a0026609

Van Gog, T., Paas, F., & Van Merriënboer, J. J. G. (2008). Effects of studying sequences of process-oriented and product-oriented worked examples on troubleshooting transfer efficiency. *Learning and Instruction, 18*(3) 211-222. http://dx.doi.org/10.1016/j.learninstruc.2007.03.003

Copyright © The Turkish Online Journal of Educational Technology

Yonker, J. E., Cummins-Sebree, S., & Walters, R. (2009). To read or not to read: How student characteristics relate to textbook reading. *AURCO Journal, 15*, 163-172.

Copyright © The Turkish Online Journal of Educational Technology