Paper Title Paper or Pixel? The Influence of Text Format and Metacognition on Student Reading Comprehension

Author(s) Phillip Thompkins, University of Maryland - Baltimore County; Linda Baker, University of Maryland - Baltimore County; Laura U, DeWyngaert, University of Maryland - Baltimore County

Session Title Learning Process and Effects of Technology-Enhanced Learning

Session Type Poster Presentation

Presentation Date 4/9/2016

Presentation Location Washington, D.C.

Descriptors Computers and Learning, Instructional Technology, Metacognition

Methodology Quantitative

Unit Division C - Learning and Instruction

Objectives

Textbooks are a staple of many an academic curriculum. As digital technologies have become more advanced and commonly available, they have been gradually integrated into classrooms. Computers, tablets, and electronic books, or *e-books,* have been incorporated into school settings as alternatives to the heavier, bulkier texts of past generations. A number of studies have been conducted comparing the influence of print and digital text formats on reading comprehension, with mixed results. This study aimed to resolve some of these inconsistencies by incorporating a within-subjects comparison alongside measurements of metacognition and monitoring accuracy. It was anticipated that should a difference exist between print and electronic formats, these differences will correlate with the metacognitive and monitoring accuracy metrics.

Perspectives/Theoretical Framework

Textbooks are more expensive than in the past, with some students entirely forgoing textbooks, despite knowing that they will be missing out on content and that their grades could suffer as a result (Redden, 2011). Some of the main reasons students prefer electronic texts are for the lower cost, the ease of access, and longevity, as a computer file is not as easily damaged as the pages of a physical book (Chulkov & VanAlstine, 2013). The students who prefer physical textbooks cite reasons like being able to turn pages, make notes in the margins, and use bookmarks, which are not replicated as fully in electronic versions (Noyes & Garland, 2005, 2006). Regardless of one's personal preference, research has shown that readers take longer to complete passages on a screen, whether a computer or a tablet, than when reading from a paper text (Connell, Bayliss, & Farmer, 2012; Mayes, Sims, & Koonce, 2001).

A large number of studies have been conducted to examine whether a physical or electronic text leads to greater reading comprehension, but the studies have not pointed towards a consistent outcome. The majority of studies have not found a major difference between the two formats, whether the studies were focused on a single course (Chulkov & VanAlstine, 2013), were longitudinal (Weisberg, 2011), or were using a variety of electronic devices (Connell, Bayliss, & Farmer, 2012; Noyes & Garland, 2003). However, a smaller portion of studies have favored physical texts for reading comprehension (Jeong, 2012) and memory recall (Morineau, Blanche, Tobin, & Gueguen, 2005); and other studies have similarly favored electronic formats (Maynard & McKnight, 2001; Maynard & Cheyne, 2005).

It is possible that the wide array of findings could be due to differences in the approaches of individual students. One important factor, examined in this study, is metacognition, or the ability to monitor and control one's own thought processes (Baker, 1989). Positive correlations have been found (Young & Fry, 2012) between scores on the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) and student grades. In addition, monitoring accuracy, or one's ability to predict performance based upon what was learned, is positively correlated with comprehension test scores (Isaacson & Fujita, 2006).

Researchers have begun to examine possible differences in metacognitive regulation when students read text in print or electronic formats.

In a recent study, published after the present study was completed, Norman and Furnes (2016) compared a variety of different formats: paper, iPad, Kindle, and PC screen and found that the platform used for reading the material had no impact on learning, perceptions of performance on assessments, or confidence in selected answers. However, because a connection was noticed between predicted likelihood of being able to spot a correct answer between users of print and screen-based readings, a second study was conducted to compare the formats further by allowing note-taking and highlighting of passages. That connection was not replicated, although the team was unable to rule out the role of note-taking. Further research has found that when under a time limit, participants using a print reading scored higher than those using a screen, and that being made aware of a time limit led to higher scores for printed readings than if the time limit was unknown (Ackerman & Lauterman, 2012). Additionally, findings point towards paper learning as both more efficient than screen-bound learning and more likely to result in accurate self-assessments of learning and knowledge (Ackerman & Lauterman, 2012).

It is also important to take into account student perceptions, both about what they are reading and about learning itself. Students generally seem to believe that they will learn more from a passage in a printed textbook than from an electronic one (Noyes & Garland, 2005, 2006; Ji, Michaels, & Waterman, 2014). Additionally, students' beliefs about the process of learning have an impact on academic performance. For example, students who believe learning is gradual as opposed to quick or not at all score higher on tests of reading comprehension Schommer-Aikins & Easter, 2006). To our knowledge, differences in epistemic beliefs have not yet been examined in comparisons of digital vs. print-based learning.

An important methodological difference between the present study and previous research on text format, is that we used a within-subjects approach. ach participant was assessed twice: once after reading a passage from a physical text and once after reading an electronic text. It was expected that this design would help resolve the inconsistencies in the literature, given that large individual differences among students would not be a confounding factor.

Method

Participants

Students from a state research university (N = 60; 40 women and 20 men) were recruited through an online participant pool and word of mouth. Participants recruited through the online participant pool were given an opportunity to receive extra credit for a psychology course. Participants were distributed throughout all stages of undergraduate coursework: freshmen (18%), sophomores (12%), juniors (30%), seniors (27%), and fifth-year students (13%). Thirty-three students (55%) were either majoring or minoring in psychology, and seven students (12%) had taken a course in community psychology at some point in their undergraduate careers.

Materials and Measures

Readings for the study were taken from the textbook: *Community Psychology: Linking Individuals and Communities, 3rd Edition*, by Kloos, Hill, Thomas, Wandersman, Elias, and Dalton. One reading was from Chapter 5, "Understanding Individuals Within Environments," and was 3,122 words in length. The other was from Chapter 6, "Understanding Community," and

had 3,029 words. Both readings were available in a physical, paperback copy of the textbook and in an online version bought from the Cengage website.

A demographics and background questionnaire was given to participants, with items focused on academic information (class standing, major, GPA), study habits (note-taking, time spent reading for classes), and preferred format (textbook, printed sheets, PDF, specialized e-book) of academic readings. Ten-item multiple-choice comprehension assessments were developed for each reading, demanding a grasp of both factual and conceptual knowledge. A post-assessment instrument to gauge metacomprehension accuracy was also created, where participants reported how many of the 10 multiple-choice questions they believed they answered correctly. The instrument also had questions about how understandable and interesting the readings were.

The Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994) was used to measure participant metacognition, and the Epistemic Belief Inventory (EBI; Bendixen, Schraw, & Dunkle, 1998) was used to determine how participants approached academic problems. The version of the MAI used is a 52-item true/false assessment of participants' metacognitive approaches, as opposed to the standard 0 to 100 scales. Items on the MAI are divided into subscales based upon knowledge (declarative, procedural, conditional) and regulation (planning, information management, monitoring, evaluation, debugging) of cognition (Schraw & Moshman, 1995). The EBI is composed of 25 6-point Likert scale questions, with response options from "Strongly Disagree" to "Strongly Agree." The EBI contains five subscales: Certain Knowledge, Innate Ability, Quick to Learn, Simple Knowledge, and Omniscient Authority.

Procedure

The study had a within-subjects design, and as such each participant completed both readings and both comprehension assessments, but each chapter was read in either physical or electronic formats. Two counterbalancing factors created four experimental conditions based on format order (electronic first or second) and passage (Chapter 5 or 6). When entering the lab, participants completed an informed consent process before completing the demographics questionnaire. Following that, participants were asked to complete the Metacognitive Awareness Inventory. Then, participants were given a maximum of 25 minutes to complete the first reading as determined by the experimental condition. Participants were given as much time as was needed to complete the comprehension test and associated post-test questionnaire. Before beginning the second passage, participants completed the EBI. As with the first passage, participants were given a maximum of 25 minutes to complete the second passage before concluding their participation with the associated comprehension test and post-test.

The time allocation for the readings was determined by having research assistants complete timed readings of both passages, adding 10 minutes, and rounding up to the next five-minute point. The allotted time was sufficient, as only 14 instances of the 120 (11.6%) resulted in a participant not finishing the reading.

Results

Comprehension Scores

A 2 by 2 by 2 mixed analysis of variance (ANOVA) was conducted to determine the effect of text format on reading comprehension scores. The within-subjects factor was text format, either physical or electronic. The between-subjects factors were order, whether a participant read the electronic text first or second, and passage, whether Chapter 5 or Chapter 6 was provided electronically. There was no main effect of format on score, $F(1, 56) = 0.62$, $p > .05$, meaning that neither physical nor electronic text format was consistently associated with higher comprehension scores. However, unexpectedly, there was a significant crossover interaction effect between format and chapter, $F(1, 56) = 12.64$, $p = .001$, partial $h^2 = .18$, , such that reading comprehension for a given format was significantly influenced by whether the passage that was read came from Chapter 5 or Chapter 6. The interaction is depicted in Figure 1. Participants scored higher on the Chapter 5 assessment after reading the physical version ($M = 5.93$, $SD = 1.28$) than the electronic version ($M = 4.83$, $SD = 1.70$). However, the reverse held true for the Chapter 6 assessment, as the scores for participants who read the electronic version ($M = 5.70$, $SD = 1.34$) were higher than the scores for those who read the physical version ($M = 5.00$, $SD = 1.89$). As is clear from the figure, there was also no main effect of passage, $F(1, 56) = 0.40$, $p > .05$, with performance determined entirely by whether the passage was read in electronic or physical format. The other counterbalancing factor, order, was not significantly associated with performance, $F(1, 56) = 0.16$, $p > .05$; it made no difference whether the electronic passage was presented first or second. The triple interaction also was not significant, $F(1, 56) = 0.16$, $p > .05$.

Correlational analyses were conducted to examine relations between comprehension scores and ratings on the MAI and the EBI. Separate correlations were run for the two MAI subscales, Knowledge about Cognition and Regulation of Cognition. Contrary to expectations, no correlations approached significance. Correlations were also run separately for the five subscales of the EBI, Certain Knowledge, Innate Ability, Quick to Learn, Simple Knowledge, and Omniscient Authority. No correlations were significant when participants read Chapter 5 in electronic format and Chapter 6 in print, but several correlations were significant in the opposite situation. Simple Knowledge was negatively correlated with assessments for Chapter 5 (physical), $r(28) = -.40$, $p = .027$, and Chapter 6 (electronic), $r(28) = -38$, $p = .039$. Additionally, Quick to Learn was negatively associated with scores on Chapter 5 (physical), $r(28) = -.40$, $p = .028$.

Monitoring Accuracy

A monitoring accuracy score was computed by taking the absolute value of the difference between each participant's score on a given assessment and the score they believed they had gotten immediately after completing said assessment. A mean monitoring accuracy score was then calculated by computing the average between each participant's monitoring accuracy relative to the chapter 5 and 6 assessments. This mean monitoring accuracy score was then included in correlational analyses with subscores on the MAI and EBI as well as with other items from the post-reading survey. When participants read chapter 5 in the electronic format, there were significant correlations between mean monitoring accuracy and four variables. Mean monitoring accuracy was correlated with confidence in answers for chapter 5, $r(28) = .48$, $p = .007$, and for chapter 6, $r(28) = .54$, $p = .002$, such that higher monitoring accuracy meant higher confidence in answers for assessments of either reading. Mean monitoring accuracy was also correlated with self-reported ability to learn the content for chapter 5, $r(28) = 0.51$, $p = .004$, and

for chapter 6, $r(28) = 39$, $p = .035$, such that higher monitoring accuracy meant a higher self-reported ability to learn the material for either reading. These correlations were not significant when chapter 6 was read in the electronic format. No significant correlations were found between any metacomprehension scores and scores of the EBQ or of the MAI.

Impact of Demographics and Reading Times

In an effort to understand the locus of the interaction effect, analyses of variance were conducted to test for possible demographic differences in performance on the print vs. electronic comprehension assessments. No effects were found for gender, English language status (English only or other languages as well), or academic major. Class standing was not related to print comprehension, but seniors has better electronic comprehension scores than other students, $F(4, 53) = 3.15$, $p = .022$, partial $\eta 2 = .192$.

Overall reading times for print vs. electronic format did not differ significantly ($M = 973.60$, $SD = 395.13$ and $M = 946.65$, $SD = 360.84$, respectively), $t(59) = -0.68$, $p = .499$. Moreover, there was not a significant difference in the length of time to read the electronic version of Chapter 5 ($M = 976.87$, $SD = 423.36$) or the print version of chapter 5 ($M = 997.20$, $SD = 336.13$), $t(58) = -0.29$, $p = .770$. Similarly, times to read the electronic version of Chapter 6 ($M = 970.33$, $SD = 372.01$) and the print version of Chapter 6 ($M = 896.10$, $SD = 382.92$) did not differ significantly, $t(58) = 0.78$, $p = .442$.

Impact of Participant Preferences for Text Format and Note-Taking

Students were asked whether they preferred reading from print or electronic texts for their classes. A large majority, 81%, expressed a preference for print over electronic formats.The preference distribution was even across conditions, so that variable does not help explain the interaction effect. There was a significant main effect of student preference on print comprehension, $F(4, 53) = 2.57$, $p = .048$, partial $\eta 2 = .163$. Those who preferred a physical printed text ($M = 6.43$, $SD = 1.39$) scored significantly higher than those who preferred an electronic textbook ($M = 4.25$, $SD = 1.50$). Those who preferred an electronic PDF ($M = 6.67$, $SD = 0.82$) scored higher on print comprehension than those who preferred an electronic textbook or no textbook ($M = 4.33$, $SD = 0.58$). All other preferences were not significantly different from one another. Format preference was not associated with comprehension scores on the electronic text, ($F(4, 53) = 0.16$, $p > .05$.

Students were also asked whether they typically took notes when reading for classes. The majority, 75%, indicated that they did. There was no effect of student note taking preference on print comprehension, $F(1, 55) = 1.00$, $p > .05$, or on electronic comprehension, $F(1, 55) = 1.83$, $p > .05$.

Significance

The central finding of this study is that we cannot resolve the inconsistencies in the literature as to whether reading texts in physical or in electronic formats leads to better learning and understanding. The interaction between text format and passage content was unexpected and as yet we have no explanation as to why it occurred. This study is the first to compare performance on physical and electronic readings in a within-subjects design, which may explain

the diverse results of similar studies that used only a single reading in a between-subjects design. Use of a single passage in a between-subjects design can give very misleading results. Had this study only used the passage from Chapter 5, conclusions would favor the electronic format, while focusing solely on the Chapter 6 passage would lead to favoring the physical format.

A potential limitation of this study is the assessments used for the readings. Limiting the metrics to 10 questions for passages each more than 3000 words meant that some topics had to be omitted or assessed with less depth. Similar studies may benefit from longer assessments to give participants more opportunities to convey their comprehension of the material. The absence of correlations between the metacognitive measures and passage comprehension was unexpected, and may need to be examined further. It is also worth noting that many similar studies reported a significant difference between reading times for physical and electronic texts, while no such difference was found from this study. This may be because each participant read both passages as part of a single experimental session, as opposed to in two separate instances. An additional concern could be the use of a time limit for readings, as Ackerman and Lauterman (2012) found that learners using paper media had higher comprehension scores than users of electronic media. Although a small portion (11.6%) of readings were not finished within the time limit, it is possible that giving participants as much time as needed to complete the passages could provide consistency to comprehension scores. An additional cause for the unusual results may be the choice to forbid note-taking and marking of the texts, because while such actions may have any confirmed impact, the vast majority of participants preferred to take notes while reading, and depriving them of that resource could have adversely influenced comprehension.

References

1. Ackerman, R., & Lauterman, T. (2012). Taking reading comprehension exams on screen or on paper? A metacognitive analysis of learning texts under time pressure. Computers in Human Behavior, 28(5), 1816-1828.
2. Baker, L. (1989). Metacognition, comprehension monitoring, and the adult reader. Educational Psychology Review, 1(1), 3-38.
3. Bendixen, L. D., Schraw, G., & Dunkle, M. E. (1998). Epistemic beliefs and moral reasoning. *The Journal of Psychology*, *132*(2), 187-200.
4. Chulkov, D. V., & VanAlstine, J. (2013). College student choice among electronic and printed textbook options. *Journal of Education for Business*, *88*(4), 216-222. doi:10.1080/08832323.2012.67293.
5. Connell, C., Baliss, L., & Farmer, W. (2012). Effects of e-book readers and tablet computers on reading comprehension. International Journal of Instructional Media, 39(2), 131–140.
6. Isaacson, R. M., & Fujita, F. (2006). Metacognitive Knowledge Monitoring and Self-Regulated Learning: Academic Success and Reflections on Learning.*Journal of Scholarship of Teaching and Learning*, *6*(1), 39-55.
7. Jeong, H. (2012). A comparison of the influence of electronic books and paper books on reading comprehension, eye fatigue, and perception. The Electronic Library, 30(3), 390–408. http://dx.doi.org/10.1108/02640471211241663.
8. Ji, S. W., Michaels, S., & Waterman, D. (2014). Print vs. electronic readings in college courses: Cost-efficiency and perceived learning. *The Internet and Higher Education*, *21*, 17-24.
9. Mayes, D. K., Sims, V. K., & Koonce, J. M. (2001). Comprehension and workload differences for VDT and paper-based reading. International Journal of Industrial Ergonomics, 28, 367–378.
10. Maynard, S., & Cheyne, E. (2005). Can electronic textbooks help children to learn? *Electronic Library, The*, *23*(1), 103-115.
11. Maynard, S. and McKnight, C. (2001a), “Children’s comprehension of electronic books: an empirical study”, The New Review of Children’s Literature and Librarianship, Vol. 7, pp. 29-53.
12. Morineau, T., Blanche, C., Tobin, L., & Guéguen, N. (2005). The emergence of the contextual role of the e-book in cognitive processes through an ecological and functional analysis. International Journal of Human-Computer Studies, 62, 329–348.
13. Norman, E., & Furnes, B. (2016). The relationship between metacognitive experiences and learning: Is there a difference between digital and non-digital study media?. Computers in Human Behavior, 54, 301-309.
14. Noyes, J. M., & Garland, K. J. (2003). VDT versus paper-based text: reply to Mayes, Sims and Koonce. International Journal of Industrial Ergonomics, 31, 411–423.
15. Noyes, J., & Garland, K. (2005). Student’s attitudes towards books and computers. Computers in Human Behavior, 21, 233–241.
16. Noyes, J., & Garland, K. (2006). Explaining student’s attitudes toward books and computers. Computers in Human Behavior, 22, 351–363.
17. Redden, M. (2011, August 23). 7 in 10 Students have skipped buying a textbook because of its cost. *Chronicle of Higher Education.* Retrieved from http://cchronicle.com/article/7-in-10-Students-Have-Skipped/128785/

18. Schommer-Aikins, M., & Easter, M. (2006). Ways of knowing and epistemological beliefs: Combined effect on academic performance.*Educational Psychology*, *26*(3), 411-423.
19. Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. Contemporary educational psychology, 19(4), 460-475.
20. Schraw, G. and Moshman, D. (1995). Metacognitive Theories. Educational Psychology Review, 7(4), 351-371.
21. Weisberg, M. (2011). Student attitudes and behaviors towards digital textbooks. Publishing Research Quarterly, 27(2), 188–196
22. Young, A., & Fry, J. (2012). Metacognitive awareness and academic achievement in college students. Journal of the Scholarship of Teaching and Learning, 8(2), 1-10.

Figure 1