Enhancing Aptitudes Through 1:1 Laptop Programs: An Assessment of Reading Comprehension and Laptop Use in Independent Schools

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Abstract

This study measured the effects of reading a text passage in digital or print format on 10th grade students from two independent schools. Randomly assigned groups each read two short passages in print or digital format and, for each, took a twelve-question comprehension quiz focused on four component areas of comprehension: vocabulary use, activation of prior knowledge, the ability to make inferences, and the ability to summarize and synthesize. Additional data about student beliefs and attitudes toward reading and technology were gathered from pre- and post-surveys. No significant differences were found between print and digital reading groups, while students with positive attitudes toward reading and strong reading aptitudes in the four component areas performed better on assessments for both media. Other attitudes toward reading and technology, as well as specific during-reading strategies, had little or no effect on comprehension outcomes.

Introduction

The failures of American schools are sometimes attributed, at least in part, to traditional teaching methods that are no longer effective for students growing up in the digital age; in other words, the argument might go, as students' methods of receiving and processing information change along with technological advances, the nature of teaching and the delivery of information in the classroom must also change. Incorporating technology into the classroom is often promoted as a way to engage students in learning. Yet this may be an unfounded and, in some particulars, untested assumption. Can technology in fact improve student learning? Does the method of information delivery and processing that technology involves really change the way teachers ought to structure instruction?

One specific reform implemented by schools moving toward greater integration of technology is the replacement of traditional textbooks and other printed material with 1:1 laptop programs in which every student uses a laptop computer and encounters material in a digital format. According to a report from the *New York Times* in 2007, for instance, two educational consultants, Hayes Connection and the Greaves Group, in a study of the nation's 2,500 largest school districts last year found that a quarter of the 1,000 respondents already had one-to-one

computing, and fully half expected to by 2011 (Hu, 2007). According to Grimes and Warschauer (2008), "One-to-one laptop programs arguably offer the greatest potential of educational technologies to date in that they place the most power and versatility in students' hands, while wireless network connections open vast new vistas for communication and collaboration" (p. 306). Certainly, such changes in the way students approach technology, and through it, texts, may have wide-ranging effects that extend into areas of budgeting, classroom management, and transportation of student materials, for instance.

More importantly, common wisdom, especially given the fledgling nature of research on the subject, provides no clear sense of how the use of laptops affects the actual delivery of academic material or students' abilities to process that material effectively when dealing with digital text and information. According to Leu (2007), for instance, "the lack of theory and research on the new literacies of online reading comprehension is surprising, given the increasing prevalence of the Internet in our lives" (p. 4). Henry (2006) further suggests that current literacy practices, in particular, do not always reflect the reading needs of students in an online world: "As new technologies increasingly become a part of classroom lessons, teachers are discovering that many students do not possess the literacy skills required to successfully read and write with the many new technologies that regularly appear in today's world" (p. 615). Included in these skills, Henry goes on to note, are the ability to search for and locate information online and new reading comprehension skills, such as reading pieces of information selectively rather than from start to finish. Coiro (2003) similarly notes that many reading issues have traditionally been seen as technology issues rather than issues of reading comprehension. Other writers (Nachmias & Gilad, 2002; Yang, 1997) suggest that students who do not possess the skills necessary to categorize and read information effectively online can become subject to frustration and information overload.

All three of the researchers in this project either teach or are administrators at schools that have instituted 1:1 laptop programs. There is an immediate need in such environments for research-based decisions about how students can best process texts—first, whether there is a significant difference for students between reading a digital text or from a print copy, and second, what strategies and resource uses teachers should be aware of when instructing students in reading for today's world.

This experience, as well as the following literature review, helped to shape both a central research question and the measure used to investigate the question: Does reading a digital text compared to printed text have a negative effect on reading comprehension for 10th grade students in 1:1 laptop programs?

Review of the Research on 1:1 Laptop Usage, Digital and Printed Text, and Reading Comprehension and Technology

Studies of reading comprehension and digital material are becoming increasingly common, though the quick-paced changes in technology may result in studies that are quickly outdated or in which the sample does not result in easy generalizations to a larger population. Middle school students in 2010, for instance, may be more adept at a variety of technological skills than middle school students ten years ago were or even than adults ten years ago were. Nonetheless, some trends have emerged in the literature that both help to refine and suggest the need for further study of the role of technology in reading comprehension. To identify these trends, we examined the literature in three areas: the nature of 1:1 laptop programs in the classroom, the differences that have been identified between reading online and reading on the page, and the elements of reading comprehension related to technology.

Research on 1:1 Laptop Programs

The use of one-to-one laptops in schools as either an enhancement to learning or as a marketing tool can be traced back to the late 1990s. At that time, evaluating entities like that of the Copernicus Project, which partnered with Toshiba and Microsoft, instituted "a multi-district laptop pilot program in Seattle, Washington, found laptops to be especially suited for writing activities, student projects, and presentations" (Fouts and Stuen, 1997). Since then, however, more and more research has been and continues to be completed around the topic of reading comprehension of students using laptops as a part of the regular high school program. While there remain financial constraints or cultural resistance at some schools who are considering laptops, other schools have either begun to phase out or eliminate their programs altogether based on a lack of increased achievement.

A review of the research on one-to-one laptop programs in high schools reveals that there have been "relatively few studies that have been carried out, and even fewer that are methodologically rigorous" (Warschauer, 2008). Given the designs the authors of this review implemented, the validity of these conclusions could be challenged, but the article nevertheless refers to a dearth of reliable, existing scholarly studies that incorporate numerous factors into their analyses. In fact, the most comprehensive study to date has been an evaluation of the laptop program in eight schools in Microsoft's Anytime, Anywhere Learning project (Rockman et al., 1998) and a statewide study of the Maine laptop program (Silvernail and Lane, 2004). Both of these studies relied predominantly on surveys and interviews to document how laptops were used, with relatively few direct observations of actual classroom practice. The conclusions of the two studies were similar and pointed to increased use of technology following implementation of laptop programs, positive attitudes toward the programs by students and teachers, more autonomous learning, and a high degree of student engagement.

Additionally, more than 30 smaller researcher studies on learning with laptops were published between 2001 and 2005 (for a listing and review, see Penuel, 2005). While Apple Computer, Inc. sponsored the review of these studies, an affiliation that could interject bias, the chief author, Bill Penuel, works for SRI International, an independent non-profit research institution specializing in research and development. Notwithstanding, the bulk of the existing research suggests that "students use laptops primarily for writing, taking notes, completing homework assignments, keeping organized, communicating with peers and their teachers, and researching topics on the Internet" (p. 3), with students who engage in more extended projects typically using "design and multimedia tools, including presentation software and software for making and editing digital images and movies" (p. 4). The implementation of laptop programs, as with other uses of technology, is highly shaped by teachers' attitudes (see, in particular, Windschitl and Sahl, 2002), and professional development is thus critical for successful implementation, as is sufficient technical support. Only a handful of studies have attempted to look at test outcomes, and those that have done so most rigorously have found no substantive gains due to laptop use (e.g., Walker et al., 2000). About the only measurable student outcome that has been shown to improve is technological proficiency (Schaumburg, 2001). In summary, though school laptop programs are growing in number, there have been relatively few independent, peer-reviewed studies of these programs. Moreover, no prior studies have carried

out extensive and systematic observations of laptop programs in a number of schools, and no prior studies have used the theoretical lens of literacy as a research focus (Warschauer, 2008)

Anecdotally, there have been positive examples across the country where "Many school administrators and teachers say laptops in the classroom have motivated even reluctant students to learn, resulting in higher attendance and lower detention and dropout rates" (Hu, 2007). However, the question of whether one-to-one laptop programs have improved academic performance is still unclear and points to the need for further evaluation.

Literature related to the differences between digital and print text formats

Studies of the differences between digital and print text formats often focus on issues tangential but related to the heart of reading comprehension, such as speed, navigation methods, and even physiological factors of reading such as eye movement or posture. Kurniawan and Zaphiris (2001), for instance, concurred with previous studies that found that reading on paper is 10-30% faster than reading online. Different column formats in this study made no difference in reading speed, however. The discussion in this study suggests that elements of online reading such as font size or level of contrast (between background and print) might affect the online reading experience. More significantly for the present study, the authors found that readers of paper texts used different methods for keeping track of where they were than did online readers, including self-guiding reading by following text with a finger or pencil. Some online readers used the mouse pointer in a similar fashion, but online readers used such methods significantly less often.

Another small-sample study of ten adult readers by O'Hara and Sellen (1997) studied annotation while reading, movement within and between documents, and the design factors that contribute to reading on paper and online, with specific findings in each area. Annotation occurred more frequently with paper reading than online reading, both on the source document itself and on a separate paper document. Movement within and between documents was found to be "quick, automatic, and interwoven" (p. 5) with paper reading as opposed to "slow" and "laborious" with online reading. Design, it was found, offered greater drawbacks for online readers, who had to plan in advance how to observe pages and who had greater difficulty with windows on the screen than with paper pages. It should be noted, however, that in the thirteen

years since this study took place and with a different generation of computer users as subjects, reading habits and practices might have changed.

Baker (2003) investigated the different effects of paging and scrolling on reading comprehension. Here again, a small, non-equivalent sample was tested through multiple choice reading comprehension questions on the effects of using a scroll function, a "paging" function (three mouse clicks required to move forward), and a "full" page function (one click required to move forward). Participants using the paging function took slightly longer to read passages than with either the full or scrolling function with no significant difference in their ability to answer reading comprehension questions correctly. The researcher found this conclusion surprising; given that it directly contradicted an earlier finding by Dyson and Kippling (1998) that paging was typically faster than scrolling. "It may be," suggested the researcher, that "since participants had more exposure to scrolling they were able to read through the documents more quickly using that mode of navigation." Here, again, it is worth considering the possibility that with rapid changes in technology and experience with technology, results of studies could reasonably change within just a few years.

From a study of 48 grade six students in an Australian school, Sutherland (2002) concluded "students perceive Web reading as different from print text reading" (p. 664). Among these perceptions were the view that reading print requires one to read more slowly (or, conversely, that digital formats require more speed), that one had to question the authority of digital texts but not of print, and that online texts should offer "instant gratification" (p. 664) while print reading required consulting multiple texts over more time. Sutherland also notes the non-linear model of digital reading, and quotes Slatin (1991), who states that "reading, in hypertext, is understood as a discontinuous or non-linear process which, like thinking, is associative in nature, as opposed to the sequential process envisioned by conventional text" (p. 158).

Evidence, then, is contradictory in terms of actual differences in method of reading between digital and print formats, though it seems clear that reader attitudes play a role in determining the methods, strategies, and perceptions involved in reading on the screen.

Literature related to reading comprehension and technology

The RAND Reading Study Group (2002) produced a report on reading comprehension that included the caveat, "Accessing the Internet makes large demands on individuals' literacy skills; in some cases, this new technology requires readers to have novel literacy skills" (p. xx). Identifying the reading comprehension skills common to both print and digital formats is therefore a key area for the present study.

Coiro and Dobler (2007), using a small sample of eleven skilled sixth-grade readers, determined that successful online reading experiences involved the application of prior knowledge sources, inferential reading strategies, and self-regulating processes (p. 215). Prior knowledge, it is worth noting, includes here not only prior knowledge of the subject but also of text structures, informational websites, and search engines (pp. 254-255). In other words, the most skilled readers bring to online reading not only the knowledge that helps them in traditional reading but also a new set of skills that assists in reading material in new, digital formats. Self-regulation, according to the study, involves prediction, monitoring (judging whether or not information has been found), and evaluation (meta-cognitive reflection on chosen reading strategies), or, in other words, "a recursive pattern of self-regulatory strategies" (p. 256).

Henry (2006) further suggests that current practices do not always reflect the reading needs of students in an online world: "As new technologies increasingly become a part of classroom lessons, teachers are discovering that many students do not possess the literacy skills required to successfully read and write with the many new technologies that regularly appear in today's world" (p. 615). Included in these skills, Henry goes on to note, are the ability to search for and locate information online and new reading comprehension skills, such as reading pieces of information selectively rather than from start to finish.

According to Schmar-Dobler (2003), "Most of the text on the Internet is expository. Being able to read such text requires familiarity with its concepts, vocabulary, and organizational format." Pearson, Roehler, Dole, and Duffy (1992) identify an additional seven strategies that can be identified with strong reading and comprehension skills, including activating prior knowledge, monitoring and repairing comprehension, determining important ideas, synthesizing, drawing inferences, and asking questions.

In conclusion, research related to this study is strongest in the area of reading comprehension for standard print texts, where decades of study have contributed to numerous frameworks that emphasize consistent aspects of reading. In all areas of technology, however, including laptop programs and reading in digital format, research is shallow, mixed in its findings, or subject to the ephemeral nature of the very material it purports to explore. With these issues in mind, we have constructed a conceptual framework for reading comprehension that informs the measures and data collection used in the current study.

Conceptual Framework

Many of the findings of the studies discussed earlier reinforce the findings of traditional studies of reading comprehension. Among the important elements of reading comprehension, this study focuses mainly on five areas that appear important to student processing of both print and online text. The first of these areas are components of reading comprehension that were tested directly using assessments on the reading passages students were assigned:

1. Activating Prior Knowledge

According to Irvin, et al. (2006), "Proficient learners build on and activate their background knowledge before reading, writing, speaking, or listening; poor learners begin without thinking." Duke and Pearson (2002) likewise agree that "good readers draw from, compare, and *integrate their prior knowledge* with material in the text" and "think about the *authors* of the text, their style, beliefs, intentions, historical milieu, and so on" (p. 206). The nature of prior knowledge, of course, may change when one is reading Internet text with hyperlinks or the ability to search for references instantly. The measures in this study thus include questions about external reference use and prior knowledge in order to help gauge the effect of this skill.

2. Making Inferences

According to Duke (2004), "making inferences" is among the central strategies that "appear to improve comprehension" (pp. 41-42). Just, Carpenter and Woolley (1982) likewise suggest that strong readers "not only encode the word but also attempt to select

a meaning, assign a syntactic status, make inferences, and determine the concept's role in the sentence and discourse as soon as possible" (p. 229). Questions that require readers to make inferences about both large and small portions of text (i.e., a single sentence or an entire passage) are measured in the present study.

3. Knowing How Words Work and Acquiring Vocabulary

"Research conducted in the past ten years reveals that vocabulary knowledge is the single most important factor contributing to reading comprehension. Moreover, studies conducted on the importance of vocabulary instruction demonstrate that it plays a major role in improving comprehension," states Laflamme (1997). Carr and Wixson (1986) add, "Because of the enormous number of words which a mature reader needs to understand, it is important for student to learn how to learn the meanings of new words." Thus, vocabulary questions are one area of the measures we have used to determine reading comprehension. In addition, since "good readers try to determine the meaning of *unfamiliar words and concepts* in the text, and they deal with inconsistencies or gaps as needed" (Duke & Pearson, 2002), we gauge *how* readers answer vocabulary questions as well as whether or not they do so correctly.

4. Summarizing and Synthesizing Information

The ability to summarize information, as well as to correctly gauge such elements of text as tone, plot, and overall meaning, directly relates to understand: "research suggests instruction and practice in summarizing not only improves students' ability to summarize text, but also their overall comprehension of text content" (Duke & Pearson, 2002). Planning and monitoring, according to Moore (n.d.), means "controlling one's mental activities; it is metacognitive in nature, centering about readers' awareness and control of their comprehension." This study measures students' ability to correctly summarize and synthesize sentences, passages, and tone.

The fifth area of reading comprehension skills was not assessed using reading comprehension quizzes, but rather through survey questions on the pre-test and post-test:

5. Monitoring and Self-Regulating Reading Strategies

Adler (2004) suggests that "students who are good at monitoring their comprehension know when they understand what they read and when they do not. They have strategies to 'fix' problems in their understanding as the problems arise." Vacca (2002) likewise states, "strategic learning during reading is all about monitoring reading and making sense. Skilled readers know how to monitor and keep track of whether the author is making sense." Because of the importance of self-monitoring as an element of comprehension, the post-reading measures of this survey ask respondents to self-describe methods of reading answering comprehension questions.

While these five areas of comprehension form the basis for the direct measures used to gauge comprehension in this study, other research covered in the literature review provides a basis for judging the method of delivery as an effect on comprehension, as well. Therefore, whether or not students annotate as they read, their perceptions and attitudes toward reading digital text as opposed to printed text, and their ability to read and answer questions within a set time frame were also established as relevant data to our conclusions.

In addition to the above areas of focus, the pre- and post-surveys students completed were designed to augment our understanding of comprehension by taking into account students' comfort level with technology and history of technology use. While the researchers hypothesized that students would perform better on the print task in conventional areas of reading comprehension such as summarizing and synthesizing and making inferences, we also hypothesized that the ability of the digital group to look up information online while reading might remove any benefits for the print group in the areas of vocabulary and prior knowledge. We anticipated that students with a higher comfort level with technology and longer history of technology use would perform better on the digital reading task than students with less comfort and less experience with technology. In addition, the researchers hypothesized that students who performed well in the five component areas of reading comprehension would perform better on either reading task, and that students who employed reading strategies (such as tracking, self-monitoring, or using a print or online dictionary while reading) specific to print or digital media would perform well on the assessment relevant to the strategies employed.

Data

This study was conducted with students at two independent, private schools: Cannon School in Concord, NC and Lausanne Collegiate School in Memphis, TN. All tenth grades students at both locations were selected for the study. Therefore, sampling did not occur, as the whole population was targeted. The number of students in 10th grade was between 60 and 82 students at both locations, respectively. The size of this group was not only manageable, as it allowed for a more accurate picture of each grade, but it also generated enough participants that concern over it being too small a survey group could be avoided. Furthermore, since the overall group was divided into a control and experimental group, sufficient size was maintained during the assignment.

By selecting all of the 10th graders at both locations, the study avoided the errors associated with sampling. The study, however, has only limited generalizability since only two small schools provided study data. Study results also do not generalize to other grades within each respective school. While generalization from this preliminary study is quite limited, results can help inform the development of subsequent studies of reading comprehension with digital texts at various grades levels and in larger populations of 10th graders in various learning environments (e.g. public, charter, or faith based private schools).

This study, conducted at the beginning of May 2010, focused on 10th grade students because two authors had ready access to these students. Barry Gilmore was the 10th English instructor and English Department Chair at Lausanne Colligate School. Matthew Rush, the Assistant Head of School/ Head of Middle School at Cannon School, was able to secure the permission of the 10th grade English teacher at his school to match the same age demographics between schools. While this selection provided ease of access to students, it also introduced the potential for bias in the study due to the fact that at least one of the researchers had a prior relationship with the subjects. Therefore in order to reduce bias, students had the ability to opt out of the research with no penalty, no grades were given for participation, and students were both anonymously and randomly assigned.

Since minors were involved with the study, parental consent forms were distributed to students to be taken home, signed, and returned to the researchers. Student consent forms were also required, per IRB regulations. A one-week window prior to the start of the study was used

to collect the consent forms and follow up with students who were slow in returning the proper documentation.

Researchers randomly assigned 10th grade students at each school to the control or the experimental group (1:1 ratio). Investigators at the two testing sites assigned every tenth grader a number at random by allowing students to draw a number from a hat as they came into class on the first day of the study. The numbers ranged from 100 to 162 at Lausanne Collegiate and 200-284 at Cannon School. These numbers encompassed the maximum number of students in the 10th grade at each respective school. From there, all of the students who drew even numbers used laptops (experimental group), while all of the students selecting odd numbers used printed text and printed resources within the room. All data collected was subsequently tracked by the random number drawn on day one.

Once groups were assigned, each student took a pre-survey designed to obtain demographic information as well as a general background of each participants ease with technology and weekly reading engagement both in and out of the classroom. The pre-survey was designed with the independent variables for this study in mind, and therefore identified students not only through the easily distinguished criteria of school and gender but also by asking questions that helped the researchers construct scales for the following variables: comfort level with technology, attitudes toward reading for school and pleasure, and history with technology and 1:1 laptop programs.

On the second day, each group read a relatively short selection from Mary Shelley's *The Last Man* in a different format (print will serve as the control vs. dynamic digital document which will serve as the experimental group). While relatively obscure, these Shelley excerpts were not assigned by the schools, but fell within the range of regular curricular reading for sophomores at each institution. Consequently, the reading had face validity as a passage that was challenging but manageable for the students. Each group was given 20 minutes for pure reading and 25 minutes to answer the questions with the reading. During that time, students could use reading strategies like underlining, taking marginal notes, or using the electronic resources available to them through their laptops (experimental group only). After the 20 minutes reading time, students were given a reading comprehension assessment designed to assess the overall dependent variable of comprehension as well as its component parts: vocabulary usage, activation of prior knowledge, the ability to make inferences, and the ability to

summarize and synthesize. Students were allowed to use other resources to help answer the questions in the assessment and still had access to the reading material during this time. Those in the control group had access to printed dictionaries within the room. However, there was no prompting by the instructor to the students to use these resources. Those in the experimental group could use the Internet - an additional resource - but again, no prompting of the instructor was given. The following were the oral instructions delivered at the start of each reading test period:

> "Today you are going to read and answer questions about a passage from a nineteenth century novel by author Mary Shelley. Some of you will use laptops to read, while others of you will read from paper. You may not discuss the passage nor ask any questions. Students who are reading the passage on paper may not use their laptops for any reason. All of you, however, may use any resources in this room other than those I have just mentioned. You will have twenty minutes to read the passage, and then you will have twenty-five minutes to answer twelve multiple-choice questions based on the reading. During the answer session, you may refer back to the text at any time."

On the third day, students repeated the experiment from day two with a second passage by the same author. The same experiment and control assignments applied. The rationale for a second administration was three-fold. First, the repetitiveness allowed researchers to test similar types of questions on consecutive days to assess validity and obtain additional data. Secondly, because both schools operate on rotating schedules, no class met at the same time of day, accounting for the intervening variable of time of day to be a non-factor. And third, because data was collected on multiple days, there were neither disturbances nor anomalies with respect to internal validity and the threat of history.

On the fourth day, students took a survey that focused on two areas, the first of which was how the students arrived at each of their answers on the reading assessment. The second half of the survey focused on questions about students' perceptions of using the type of text assigned. All surveys and reading assessments were collected at the end of each period. This resulted in a high percentage of data being successfully completed.

Based on research from the literature review and the questions proposed by the research itself, information was collected on the dependent and independent variables outlined in Appendices A and B and described below.

The format in which texts were delivered to the two groups of tenth graders was the independent variable. This group was controlled by their enrollment in a 1:1 laptop, independent school and their grade level, 10th grade. Both groups read the same text, each in a different format, followed by reading comprehension tests. Pre- and post-surveys helped to account for possible intervening variables such as the school attended, gender, comfort with and experience with technology, and each student's personal attitudes toward reading in general. Random assignment accounted for other variables such as class period (time of day) or class size. The dependent variable was reading comprehension, as judged from reading comprehension quizzes made up of a variety questions suggested by the five categories of comprehension presented in the literature review: activating prior knowledge, making inferences, vocabulary, summarizing and synthesizing, and monitoring and self-regulating. Appendix C shows how the survey questions align to the research questions of this study and the various dependent variables herein.

The pre- and post-surveys mainly included questions about students' comfort level and history with technology and reading, as well as attitudes and perceptions about technology. These surveys were an amalgamation of previously developed survey questions from Coiro (2003), Harris and Smith (2004), Silvernail and Lane (2004), and Grimes and Warschauer (2005). In particular, the pre-survey questions, besides establishing basic background information (gender, school, and age), aimed to collect data about history and comfort level, while the post-survey focuses on reading strategies and methods of technology use during reading. Scales used for these measures are included in Table 1 along with the corresponding Cronbach's alpha scores. While the scales for "positive attitude toward reading" ($\alpha = .680$) and "comfort level with technology" ($\alpha = .704$) were used as planned from the initial design of the surveys, the scale for "self-monitoring and regulating" ($\alpha = .697$) proved more difficult to compute. Initial scales based on the sets of variables intended to measure various aspects of tracking and self-reflection while reading proved to demonstrate very little reliability between the various survey items. The scale that is presented in this study is a measure of self-monitoring while reading print texts in particular and includes both tracking activities and enjoyment during reading as individual components of the scale.

A final measure, given on the fourth day, asked students to respond to each of the 24 reading comprehension questions with an explanation of how the question was answered. The goal of this brief response set was to determine when students were using prior knowledge, technology skills, or simply guessing.

Appendix A includes means, standard deviation, and sample size for each of the dependent and independent variables. The limitations offered by small sample sizes in some areas of the analysis are addressed in the results section of this paper.

Methods

In order for the reading comprehension quiz scores to be compared with other variables more easily, the raw answers to the quizzes were rescaled in three ways. First, each question (originally a four-option multiple choice question answered by students) was rescaled into a categorical variable indicating a correct or incorrect answer. Using these new categorical variables, a new raw score out of 24 questions was established for each student (this variable was used for Tables 4, 5, and 6). A mean score was then determined for all students (slightly above 13 questions correct) and a subsequent categorical variable was created, identifying students who scored above or below the mean score (used in Table 2). Finally, each student's answers to questions specifically addressing vocabulary use, prior knowledge, making inferences, and summarizing and synthesizing were extracted to create scales for aptitude in each of those areas for each student (Tables 5 and 6).

A number of variables based on student answers to pre- and post-survey questions were also rescaled into categorical variables. For instance, many of the statements students answered on a scale of 1-5 (for which 1 = "strongly agree," 2 = "agree," 3 = "neutral," 4 = "disagree," and 5 = "strongly disagree") were rescaled into categorical variables on which students either agreed with the statement in some fashion, or not. This allowed us to run chi square comparisons in Table 2, for instance, as well as using the original scaled variables where relevant.

Additionally, the three scales described in Table 1, all of which were essential to our original hypotheses, were created using a number of variables from the pre- and post-surveys.

With these variables in place, a number of statistical analyses were run. What follows is a rationale for each of the five statistical Tables (2-6) found in this paper.

Table 2 presents chi square values for the categorical variables representing self-identified reading characteristics; the values for these variables were first compared to the variable representing student above the mean test score and then to one another. Because the most important information sought in this table was a) simply whether or not positive or negative attitudes had any effect on other attitudes and on general test performance and b) whether specific during-reading strategies mattered at all to performance, simplifying these variables to positive or negative responses to various statements allowed us to compare nuanced student responses with more certainty. Our primary concern in creating this table was to determine whether or not relationships occurred by chance or whether the effects of strategies and attitudes on one another were statistically significant. In particular, by using categorical variables and chi square values, we were able to see whether positive attitudes correlated with other positive attitudes and positive beliefs toward strategies with other positive beliefs. Using the above mean variable for test scores in this table also allowed us to use the variables to determine a general correlation with academic performance and reserve more nuanced analysis of test scores using scaled data for later tables.

Tables 3 and 4 used original scaled variables to indentify reading attitude and attitudes toward technology. Because we were not seeking to determine causation but only covariance, Pearson's correlation was used for both Tables 3 and 4 as a way of determining the extent to which one could reasonably assume that students who exhibited one trait while reading or using technology might also exhibit another. Using these statistics, the size and direction of relationships between particular attitudes toward reading and technology could be determined.

Finally, Table 6 used descriptive data for a number of dependent and independent variables to compare t-test statistics between various groupings of students and the overall group. Using t-test analysis allowed us to divide the population into print and digital groups and make comparisons based on the means of a large number of variables to determine whether statistically significant relationships existed between them.

Using this variety of analytical approaches allowed us, in some cases, to double-check the validity of our findings by including some variables on more than one table. The picture that grows out of the five tables is more cohesive than any one table and offers more certainty about the relationships between several more abstract variables such as attitude, feelings, and beliefs with more objective data such as quiz scores. Since some results were unexpected or

contradicted our original hypotheses, it was important to view the data through a variety of lenses to confirm our understanding of the extent to which attitudes and aptitudes in reading comprehension and technology affect one another.

Results

In an effort to gauge not only successful reading but also the effect of student predispositions on reading activity, results of this study broken down into three primary categories: 1) student attitudes and beliefs toward reading, 2) student attitudes and beliefs toward laptop and technology use, and 3) reading skills and aptitudes as they relate to reading comprehension of print and digital media. While there is overlap between these three groups, the distinction between student attitudes and actual performance is important because it highlights the differences between perceptions students have of their own abilities and the abilities themselves. More about the relationship between the three areas of the study is addressed in the conclusion of this paper, while limitations of this study are addressed at the end of this section.

Initial analysis of data was performed using t-tests, scatter plots, and other graphs to check for directions of relationships and, in some cases, to make sure random selection was verified within and between schools. For instance, one of the first analyses the researchers conducted was meant to ensure that school attended and gender had no effect on test scores, thus ensuring that random selection had worked (Figures 1 & 2). No significant difference was found for quiz scores based on either of these criteria.

Another initial set of data we checked were the reading comprehension components for differences in means (see Figure 3). Here, charting the data offered an initial idea of differences (or lack thereof) between the print and digital reading groups, allowing us to determine that more nuanced analysis using t-tests would be useful in this area to determine whether some differences were statistically significant or not.

Other important initial checks of data included creating a scatter plot for the fifth component of comprehension (self-monitoring), based on the scale identified in Table 1 (Figures 4 and 5), and two other important variables in the study, comfort with technology (Figure 6) and comfort with reading (Figure 7). Here, the initial appearance of the data on scatter plots raised the possibility of interesting findings. Specifically, the data appeared to refute the hypothesis

that students who express greater comfort with technology would score higher on the quiz. In fact, it appeared that lower levels of comfort with technology equated to higher scores, as was later confirmed by the t-test analysis conducted in Table 6. Moreover, students with greater enjoyment of reading also scored higher; a trend that was also confirmed by later analysis. Each of these initial reviews of data set the stage for determining methods of data analysis to be used in the remainder of the study.

Student attitudes and beliefs toward reading

Table 2 presents the interaction between self-identified reading characteristics of students (from the pre- and post-surveys completed by all students in the study) and a) the students who scored above the mean score of 13 out of 24 questions correct on the combined reading comprehension quizzes, and b) other self-identified reading characteristics. For this table, scaled variables that asked students to strongly agree, agree, disagree, strongly disagree, or state neutrality on the issue were simplified into categorical variables, where strongly agree and agree were considered a "positive" response and all other responses are considered "negative." Likewise, raw test scores for each student were converted to a categorical variable in which students were identified as scoring above or below the mean score of 13. Using these categorized variables, it was possible to run chi-square analyses on all variables presented in the table.

Two areas of interest arise from the results of table. First, the relationship between self-identified characteristics of student readers and those who scored above the mean is worth attention. Statistical significance was achieved for two variables—"enjoys reading" and "is productive"—and even then, only the variable "is productive" (the full statement on the survey read, "I am more productive when I use my laptop") was significant at the level of $p < .05$, while "I enjoy reading for school" was significant at the level of $p < .10$. On all other variables, no statistical significance was found.

What becomes apparent in this table and is reinforced throughout the study is the general finding that students' perceptions of their own reading, as well as their specific strategies while reading, mattered less (if they matter at all) for this reading task than did their general enjoyment of reading and their aptitudes in specific areas of reading comprehension (as detailed in Tables 5

and 6). The unique finding of significance between students who self-identify as being more productive when using laptops and students who scored above the mean is possibly just what it seems, a correlation between those strong readers both in print and digital text and those who consider themselves more productive using technology. A possible explanation could include the idea that laptops help good students—who might already be organized—organize even better, or simply that productive students in general are likely to be among those who are also productive when taking reading comprehension tests, for instance.

What is equally clear from the table, however, is that other self-identified characteristics do not correlate with high scores on the quizzes. Among these are during-reading strategies such as text tracking using a finger or mouse, looking up words while reading, and reading slowly. In addition, a history with laptops as reading or school tools, including becoming distracted in class when using a laptop and having used a laptop in school for more than two years (in other words, since middle school) does not correlate to above-average reading comprehension scores. Most interestingly, perhaps, the self-perception of increased or decreased comprehension while reading digital text does not translate into an effect on actual performance on the reading comprehension assessments. What emerges from these findings is that on a response to a text of this style and length, attitudes and strategies tend to not to have an effect on overall scores.

The second major area of interest raised by the chi-square results of Table 2 is the relationship between individual self-identified characteristics. Here, significant correlations appear only between self-perceived improvement on comprehension with digital text and three of the other variables related to digital reading: productivity, reading slowly, and using a dictionary. What is important to note is that all of the variables identify perceptions students have of themselves, not actual improvements in reading. Thus, students who *feel* that they read more slowly with a digital text also *feel* that they comprehend more (at a highly significant level of $p < .01$), just as students who claim to look up more words when text is digital feel they comprehend more (at a less significant level of $p < .10$). Thus, self-perceived strategies affect self-perceived attitudes, but neither the attitudes nor strategies can be proven to have actual effects on the reading task itself.

For every other self-perceived reading characteristic in Table 2, no statistical significance can be shown for effect on other characteristics. This finding is somewhat surprising since one might expect student attitudes to correlate—those who have used laptops for more than two

years, for instance, might be expected to track text or read more or less slowly with some consistency, but such is not the case. Rather, it seems likely that all students have enough experience with technology that reading strategies remain broadly distributed throughout the population in the study. It is also interesting that those who claim to enjoy reading for school do not comprise the same group (in a statistically significant manner) as those who see themselves as comprehending digital text better than print text, possibly because reading for school in an independent school, 1:1 laptop program consists of both print and digital text to large extent.

Table 3 presents Pearson correlation coefficients that evaluate the strength of relationships among key questions about reading enjoyment. As with Table 2, there were surprisingly few strong relationships, though some moderate or weak correlations emerge. Specifically, the results suggest that a student's level of enjoyment of reading print correlates with his or her level of enjoyment of overall reading ($r = 0.325$), a finding of moderate strength, but it does not suggest correlation to the usefulness of laptops with regard to reading assignments ($r = .025$). While the relationship between enjoyment of print reading and overall reading is significant, even these seemingly closely related variables possess just a moderate level of significance (between .30 and .49 level). Additionally, when comparing a student's enjoyment of reading digital material for pleasure to usefulness of the laptop on reading assignments, the computation produced a technically significant statistic ($r = -0.315$) at the .01 level, but only a moderate level of significance is suggested.

Interestingly, Table 3 also shows additional findings of correlations among general attitudes and beliefs toward reading. In comparing enjoyment of reading for school and the laptop's usefulness for schoolwork, the Pearson correlation coefficient ($r = .230$) is technically significant at the .05 level. Again, however, this is a small level of significance (between .10 and .29 level). Moderate levels of significance ($r = .304$) at the .01 level, were also produced between student's enjoyment of reading for school and usefulness of the laptop for reading. The usefulness of the laptop for schoolwork compared to the usefulness of laptop with reading generated a similar, moderate level of significance ($r = .331$) at the .01 level. This correlation is only surprising, perhaps, in its lack of strength—though schoolwork and reading are not synonymous, one might expect a close relationship to exist in student perception between them.

Further analysis on the question "I enjoy reading printed material for non-academic pursuits" compared to self-evaluation of technology ability reveals a lack of dramatic significance (r = .158), further corroborating the earlier findings.

The overall impression that emerges from Tables 2 and 3, then, is that student attitudes toward reading—with and without technology—are variable. These attitudes are generally unrelated to actual reading comprehension ability nor to numerous other attitudes about reading in print or with technology. Contrary to this general finding is the finding that students who enjoy reading do perform better on actual reading tasks in either media, digital text or printed text.

Student attitudes and beliefs toward laptops and technology use

Table 4 yields specific data around general attitudes toward technology and personal laptop usage, using questions taken from the pre-survey. In general, the data suggests that total quiz scores do not correlate with attitudes toward technology. In other words, it does not seem to matter whether students like using laptops or not when they actually perform reading tasks. In the case of only one variable does this general trend not hold true; test score data does correlate with responses to the statement, "The quality of my schoolwork is better as a result of my laptop," but only at the most minimal level on the Pearson scale (r = .206).

However, unlike attitudes and beliefs toward reading, a number of attitudes and beliefs toward technology correlate with statistical significance against one another. While the feelings that students have toward laptops may not affect their academic performance, those feelings do affect other attitudes and beliefs, some strongly and others only moderately.

There was a strong correlation (r = .546), for instance, between student feelings that schoolwork is more interesting with laptops and their sense of improved understanding with laptops. Increased interest in schoolwork and students feeling more involved as a result of using their laptops also produced a strong correlation (r = .550). Additional strong correlations were found between students' feelings of understanding schoolwork better with laptops and their involvement (r = .535) and productivity levels (r = .547) being stronger as a result. None of these correlations is particularly surprising—the pattern that emerges is one in which students

who feel positive about using laptops in some ways also feel positive in other ways—they feel more interested, and therefore more involved; they feel involved, and therefore more productive.

While the aforementioned data has strong significance, most of the other questions regarding laptop usage reveal significance only in the low-moderate range.

Students' beliefs that schoolwork is more interesting with their laptops, for instance, compared to feelings of being more productive with their laptops, yielded moderate results ($r = .330$). Similar findings also appeared when interest level was compared to the quality of work produced ($r = .347$). Perceptions of understanding schoolwork better with laptops and improved quality of schoolwork also yielded moderate significance ($r = .483$), as did perceptions of being more involved with feelings about being more productive ($r = .486$) and producing quality schoolwork ($r = .482$). A final moderate correlation was produced between feelings of productivity and a belief that the quality of schoolwork improves with laptops ($r = .433$).

Again, none of these correlations is particularly surprising. Students who enjoy using their laptops tend to reinforce some positive attitudes about technology with others. It bears repeating, however, that just because positive attitudes about technology fortify one another, they do not necessarily weigh upon actual performance.

One group of findings from Table 4, those involving distractibility, are interesting because of their lack of statistical significance. Distractibility is one marker that is often suggested as a downside of 1:1 laptop programs; one popular article on laptop use, for instance, suggests that "Inside the classroom, technology may be a disruptive innovation in ways not intended… pervasive multi-tasking between laptop, smart-phone and other technologies in the classroom often distracts students (Glenn, 2008). However, the research conducted in our study suggest that a sense of distraction does not bear any statistical significance on total quiz scores or on other variables, other than a very small negative correlation ($r = -.220$) when compared to productivity in school. Otherwise, the distractibility students do or do not encounter because of laptops does not highly correlate with any other attitudes or beliefs about personal laptop usage. To buttress this finding, the chi-square data in Table 2 illustrates that neither the self-perception of students being distracted by laptops nor their experience level with laptops possesses statistical significance when compared to the score on the reading quizzes.

Reading Aptitudes and Academic Performance

For the purposes of this study, academic performance does not equate to overall grade average for the year, previous academic history, or any standardized testing data. Rather, academic performance refers strictly to the results on the two quizzes students took after reading the Shelley passages. These quizzes were designed, however, to address a variety of reading aptitudes and strategies that students might display, a number of which are addressed in Table 6.

Table 6 offers both descriptive data for major variables related to reading comprehension (also included in Appendix A) and also t scores for the difference in means between student performance based on those variables and the performance of all students. The table includes three models: one for the print readers only, one for the digital readers only, and one for all students (both media types combined). The number of students who fit the description provided by each variable is provided in part because for some variables, the sample size is quite small and may therefore offer some limitations in the findings.

The first half of Table 6 gauges the difference in means based on dependent variables in the study. Practically none of the variables tested here proved to be significant in affecting reading comprehension scores—gender, school, history with laptop usage, and a high comfort level with technology included. It should be noted that among the dependent variables included on this chart, attitudes toward reading and comfort level with technology may stand out as attributes over which students have no or little control, unlike gender. Nonetheless, because student scores on these variables were determined using student pre-test responses to questions on a pre-designed scale (see Table 1), these characteristics are here treated as attributes that students carried with them into the testing that could not reasonably be expected to change between the start of testing and the end of the study.

Ultimately, only two of these characteristics affected scores at a statistically significant level. First, students who identified themselves as possessing a positive attitude toward reading (a small group at 24 students, or around 18% of the total population) scored higher. Especially significant here is the print group, whose attitude is significant at the level of $p < .01$, as is the attitude of the combined groups, while the digital group's positive attitude is significant at the level of $p < .05$. Given earlier findings from the study referenced earlier, this finding is not particularly surprising; students who like to read appear to have scored higher on the quizzes.

Worthy of note here, however, are two aspects of the finding. First, while the statistical significance for the print group is higher than for the digital group, both results are statistically significant at conventionally recognized levels. In other words, a positive attitude toward reading affects scores of all readers, regardless of the type of media read. Secondly, a negative attitude toward reading appears to have no measurable effect on scores—students with a positive attitude score high when compared to all students, but students with a negative attitude cover a broad spectrum of performance.

A perplexing finding is that possession of a high comfort level with technology showed no effects on performance, but a low comfort level did affect scores (Table 6). Moreover, for students in the print group, a low level of comfort with technology is significant at the level of $p < .01$, while for the digital reading group a low comfort level with technology is not significant by conventional measures at all. Without further study, it may be fruitless to speculate about this finding, which seems to run contrary to all expectations (surely one would expect students with a low comfort level with technology to do worse on the *digital* reading task, not the print task). Nonetheless, this finding reinforces other findings from the study that suggest student self-perception is not the most important factor in determining reading performance—though a positive attitude about reading may affect performance, precious few other attitudes, including the attitude toward technology, seem to prove reliable indicators of student performance on reading comprehension.

The search for reliable indicators may find its most secure footing, however, in the second half of Table 6, where t scores of reading comprehension aptitudes are compared to overall performance of the entire group. Here, on four major aspects of reading comprehension—vocabulary recognition and use, the ability to make inferences, the application of prior knowledge, and the ability to summarize and synthesize information—every variable in every model save one proved significant at the $p < .10$ level, at least, with most registering at the level of $p < .05$ or $p < .01$.

To better understand these effects, the results displayed in the latter half of Table 6 may be considered in three parts made up of two variables each. The first are the variables for the ability to make inferences and the ability to summarize and synthesize information. A “strong” display of these skills here indicates that students answered at least 3 out of every 4 questions in this area correctly. These variables stand out for two reasons: first, because the level of

corresponding significance between the mean scores in these areas and of all students share the most compelling levels of significance of all data in this part of the study, and second, because neither of these variables could be manipulated by student use of external resources during the quiz or reading itself. Making inferences and synthesizing require students to employ critical thinking skills, reading expertise, and savvy, not search engines or dictionaries. For this reason, these aptitudes may be taken to reflect actual student ability, not the tools students possessed in class.

A second set of variables to consider as a pair are those for vocabulary use and activation of prior knowledge. While statistical significance levels suggest that strength on these variables effects test score means, it should also be noted that questions corresponding to these skills could be answered using either technology or other resources with the classroom. In particular, numerous students used some resource to look up vocabulary words *once they saw the words on the quiz* (as opposed to while reading). Some questions, such as one which required students to identify the King of England at the time of Shelley's composition, probably required either prior knowledge beyond the typical scope of a tenth grade student or required knowledge gained through Internet use—this explains, perhaps, the more significant relationship of this area to means scores among digital readers, who also possessed access to the Internet.

Finally, the third pair of variables, the ability to monitor and self-regulate and the proactive use of resources while reading, show no statistically significant link to overall performance. As suggested earlier, it seems that strategies have less application to reading comprehension of this sort than for proclivities of reading or elements of reading tasks therein.

The findings from this study must be taken within the context of several study limitations. High school students in most independent schools feel degrees of pressure, be it from parents, the school, themselves, or a combination therein. While we attempted to have a low-stress environment by not counting the grades on the quizzes toward the students' academic average, there is always the possibility of cheating. Though students were monitored at all times during the sessions, looking up information was allowed in this exercise, using either print or digital media according to the random selection groupings. Similarly, the fact that the quizzes did not count for grades may have also altered students' efforts in this exercise. As a result, though hard to measure, a level of apathy must be considered in analyzing the final results of the reading quizzes.

Time of year is an additional limitation. The month of May presents students who experience greater fatigue, are preparing for end-of-year exams, are concluding interscholastic athletic seasons with district and state playoffs, and have just finished or are preparing for AP exams—not to mention that most are looking forward to their summer vacation. Couple this with the potential for the students to see the Shelley passage as boring or irrelevant, and additional confounding variables are presented.

Chosen to be a balance of having relevance to the curricula at both schools and being hard to find on the Internet (answers to questions, reading notes, etc.), The Shelley passages may also have provided limitations. Due to the difficulty with narrative structure in fictional texts, only one chapter from the book was used for reading selections. This takes the text out of context from the rest of the story, which could confuse students or lack relevance. Thus, using a shorter story in order to cover the whole text may have provided greater interest, more relevance, and different results on the reading quizzes. In addition, a non-fiction text or poem could produce different results in terms of comprehension and attitudes.

Finally, we acknowledge that the sample size, while acceptable, was relatively small, particularly in analyzing some of the variables. While we are confident in the results, additional testing should be done on greater numbers of students.

Conclusions

The study was designed to determine whether independent school sophomores would perform better on reading comprehension tasks and assessments after reading a text in either digital or print format. Ultimately, no appreciable difference could be distinguished between student comprehension and the two types of text; the hypothesis that students would perform better on the print task than the digital task was proven false. Neither simple test score results on the responses to digital and print texts nor the results filtered through other variables, such as attitudes and beliefs, demonstrate that students perform better after reading in one media versus another.

What clearly does affect reading comprehension in both media, however, are four component areas specific to comprehension and reading ability: vocabulary use, activation of prior knowledge, the ability to make inferences, and the ability to summarize and synthesize. The hypothesis that strength in these areas would improve scores on quizzes in either media was

proven true; strength in these areas produces strong comprehension of texts whether those texts are encountered on the screen or on the page.

On the other hand, reading strategies and specific methods of reading have little or no effect on actual performance and comprehension on this type of reading task. The hypothesis that student strategies such as note taking, tracking while reading, and self-monitoring would affect performance on comprehension of either print or digital text was proven false. Where strong reading aptitudes are therefore crucial to understanding of texts in any format, students' self-selected strategies while reading cannot be shown to affect this type of reading comprehension task for this population of students.

The study also took into account the importance of student self-perceptions on their comprehension and laptop use. In addressing the question of whether reading aptitudes are more valuable than reading attitudes, some interesting differences may be noted.

While the hypothesis that overall positive attitude toward reading can be shown to have some positive effect on performance on reading comprehension tasks of this type proved true, attitudes toward reading generally make little difference in determining how students will perform in reading digital or print texts specifically. Reading attitudes also affect other reading attitudes only sporadically, generally making it difficult to draw large-scale assumptions about student performance from beliefs about their own reading habits.

Student beliefs and attitudes toward technology correlate more consistently with one another. Again, these attitudes cannot be demonstrated to produce an effect on actual academic performance and therefore the hypothesis that higher comfort levels or longer history with technology would increase scores was proven false. However, the results do suggest that positive attitudes toward laptop programs reinforce other positive attitudes toward those programs.

This study offers possible implications for independent schools in general and for teachers and their daily practice in particular. Study results do not recommend for or against the use of laptops in schools. Study results with respect to reading comprehension suggest that the tool used for comprehension is less important than the attitudes, self-perceptions, and aptitudes. Like many other excellent tools used by teachers to engage students, stimulate thought, and differentiate learning, laptops appear to also fall into that same category. We would also advocate for additional research among additional independent schools with 1:1 laptop programs.

This would allow a larger sample size, as well as an opportunity to test a different reading passage. Schools with laptop programs and strong technology programs frequently make decisions, however, about buying texts, assigning digital homework, and allowing students to read online in class. The results of this study suggest that school administrators and teachers should tread carefully in making assumptions about the comprehension abilities of students based solely on the media through which a text is presented. This study can neither confirm nor argue against the decision a school might make, for instance, to replace paper copies of entire novels with online (and often free) versions of the text.

Further, setting up a similar study at different independent schools may point to strategies certain English teachers use that are either deleterious or advantageous to students, based on the students' scores on reading comprehension quizzes. While specific reading strategies did not appear to offer significant advantage to students on this particular reading task, that does not mean that such strategies do not work well with other forms of text or in improving the component areas of reading comprehension over time. It is entirely possible, for instance, that tracking skills improve reading in general over a period of years, with longer or shorter texts only, or with text that appears in a visually demanding format such as multiple columns.

Reading comprehension is a complex, multi-faceted task, as is technology use. Practicing professionals should be aware that even as current research is completed regarding the interaction between reading and laptops, students themselves are likely changing their habits, attitudes, tools, and skills related to technology. While this study suggests that digital reading of short passages may be a viable alternative to using print text for some independent school classes, teachers and school officials should watch the relationship between reading and laptop programs carefully in the coming years.

References

Adler, C. (2004). Seven strategies to teach students text comprehension. *Reading Rockets: Reading Comprehension & Language Arts Teaching Strategies for Kids*. Retrieved April 18, 2010, from http://www.readingrockets.org/article

Carr, Eileen & Wixson, Karen K. Guidelines for evaluating vocabulary instruction. (April 1986). *Journal of Reading.* pp. 588–595.

Coiro, J. (2003). Rethinking comprehension strategies to better prepare students for critically evaluating content on the Internet. The NERA Journal, 39(2), 29–34. http://us.mg2.mail.yahoo.com/dc/launch?.rand=0fh6oerrpmnnv - bib3up#bib3up

Dole, J.A., Duffy, G.G., Roehler, L.E., & Pearson, P.D. (1991). Moving from the old to the new: Research on reading comprehension instruction. Review of Educational Research, 61, 239-264.

Dyson, M.C. & Kippling, G.J. (1998). The effects of line length and methods of movement on patterns of reading from screen. Visible Language, 32, 150-181.

Duke, N.K., & Pearson, P.D. (2002). Effective practices for developing reading comprehension. In A.E. Farstrup & S.J. Samuels (Eds.), *What research has to say about reading instruction* (3rd ed., pp. 205-242). Newark, DE: International Reading Association.

Duke, N. (2004). The case for informational text. *Educational Leadership,* 61(6), 40-44.

Fitzgerald, M. et al (2002). Educational Media and Technology Yearbook: Volume 27. Englewood, CO: Greenwood Publishing.

Fouts, J.T. & Stuen, C. (1997). *Copernicus Project: Learning with laptops. Year 1 evaluation report.* Seattle, WA: Seattle Pacific University. (ERIC Document Reproduction Service No. ED 414 847)

Glenn, M. (2008). The future of higher education: how technology will shape learning. *The Economist Intelligence Unit*. New York, NY: New Media Consortium.

Grimes, D. & Warschauer, M. (2005). Fullerton School District Laptop Program First Year Evaluation Report - University of California, Irvine Department of Education. October 20, 2005.

Grimes, D., & Warschauer, M. (2008). Learning with laptops: A multimethod case study. *Journal of Educational Computing Research 38*(3), 305–332.

Harris, W.J., & Smith, L. (2004). Laptop use by seventh grade students with disabilities: Perceptions of special education teachers: Research report #2. Orono, ME: Maine Education Policy Research Institute, University of Maine Office.

Henry, L.A. (2006). SEARCHing for an answer: The critical role of new literacies while reading on the Internet. *The Reading Teacher, 59,* 614–27.

Hu, W. (2007). Seeing no progress, some schools drop laptops. *The New York Times*. Retrieved April 17, 2010, from http://www.nytimes.com/2007/05/04laptop.html

Irvin, J.L.; Lunstrum, J.P.; Lynch-Brown, C. & Shepard, M.F. (1996). *Enhancing Social Studies Through Literary Strategies.* (p. 5). Washington D.C.: National Council for the Social Studies.

Just, M.A., Carpenter, P.A. & Wooley, J.D. 1982. Paradigms and processes in reading comprehension. *Journal of Experimental Psychology: General*, 3, 228- 238.

Laflamme, J.G. (1997). "The Effect of Multiple Exposure Vocabulary Method and the Target Reading/Writing Strategy on Test Scores." *Journal of Adolescent and Adult Literacy,* 40 (5). pp. 372–381.

Leu, D.J. et al. (2007). What is new about the new literacies of online reading comprehension?. *Secondary school literacy: what research reveals for classroom practice* (pp. 1-18). Urbana, IL : National Council Of Teachers Of English.

Moore, D.W. (n.d.). Reading comprehension strategies. *Hampton-Brown Edge*. Retrieved April 18, 2010, from http://www.hbedge.net/profdev/guides

Nachmias, R., & Gilad, A. (2002). Needle in a hyperstack: Searching for information on the World Wide Web. Journal of Research on Technology in Education, 34, 475–486.

Penuel, W.R. (2005). *Research: What It Says About 1 to 1 Learning.* Cupertino: CA: Apple Computer, Inc. Available online at: http://www.ubiqcomputing.org/Apple_1-to-1_Research.pdf

RAND Reading Study Group. (2002). Reading for understanding: Toward an R&D program in reading comprehension. Retrieved April 15, 2010 from http://www.rand.org/multi/achievementforall/reading/readreport.html

Rockman, et Al (1998). *Powerful tools for schooling: Second year study of the laptop program-A Project for Anytime Anywhere Learning by Microsoft Corporation: Notebook for Schools by Toshiba American Information System.* Rockman, et Al, San Francisco, CA.

Schaumburg, H. (2001). Fostering girls' computer literacy through laptop learning: Can mobile computers help to level out the gender difference. Paper presented at the National Educational Computing Conference, Chicago, IL.

Schmar-Dobler, E. (2003). Reading on the Internet: The link between literacy and technology. Reading Online, 17-23. Retrieved April 15, 2010 from www.readingonline.org.

Slatin, J. (1991). Reading hypertext: Order and coherence in a new medium. In P. Danley and G. Landow (Eds). *Hypermedia and literary studies* (pp. 153-170). Cambridge, MA: MIT Press.

Silvernail, D.L. & Lane, D.M.M. (February 2004). *The impact of Maine's one-to-one laptop program on middle school teachers and students*. Retrieved from www.state.me.us/mlti/articles/research/MLTIPhaseOneEvaluationReport2004.pdf

Vacca, R.T. (2002). “Making a Difference in Adolescents’ School Lives: Visible and Invisible Aspects of Content Area Reading.” In A.E. Farstrup & S.J. Samuels (Eds.). *What Research Has To Say About Reading Instruction* (3rd ed., pp. 184–204). Newark, DE: International Reading Association.

Walker, L., Rockman, S., & Chessler, M. (2000). A more complex picture: Laptop use and impact in the context of changing home and school access. The third in a series of research studies on Microsoft’s Anytime Anywhere Learning Program. San Francisco, CA: Rockman, et Al.

Warschauer, M. (2008). Laptops and Literacy: A Multi-Site Case Study *Pedagogies: An International Journal,* 3, 52-67.

Windschitl, M. & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal, 39* (1), 165-205.

Yang, S. (1997). Information seeking as problem solving using a qualitative approach to uncover the novice learners’ information-seeking processes in a Perseus hypertext system. Library and Information Science Research, 19, 71–92.

TABLE 1
Scales Used in the Analysis

	Cronbach's Alpha
Positive Attitude toward Reading	.680
Included Variables:	
1. I enjoy reading printed material for non-academic pursuits.	
2. I read the entire Shelley passage carefully, skipping or skimming no parts.	
3. I enjoyed reading the Shelley passage.	
4. I read three or more hours for pleasure each day.	
Comfort with Technology	.704
Included Variables:	
1. I enjoy reading digital material for non-academic pursuits.	
2. I find using a laptop during the school day to be helpful with schoolwork.	
3. I find using a laptop during the school day to be helpful with reading assignments in particular.	
4. I am more productive when I use my laptop.	
5. The quality of my schoolwork is better as a result of my laptop.	
Ability to Self-Monitor While Reading Print Texts	.697
Included Variables:	
1. I take more notes when the text is in print.	
2. I am more likely to look up words I don't know when the text is in print.	
3. I am more likely to look up references to information I don't know when the text is in print.	
4. I read more quickly when the text is in print.	
5. I enjoy reading more when the text is in print.	

TABLE 2

Interaction between Self-Identified Reading Characteristics of 10th Grade Independent School Students (Chi Square Values)

Variables[1]	*Above Mean Comp Score*[2]	*Is productive*	*Is distracted*	*Reads slowly*	*Tracks text*	*Uses dictionary*	*Comprehends (self-perception)*	*Has experience*
1. Enjoys reading	.073*	.825	.525	.349	.461	.526	.347	.965
2. Is productive	.022**		.225	.125	.681	.774	.002**	.573
3. Is distracted	.588			.395	.233	.435	.604	.288
4. Reads slowly	.713				.261	.550	.000***	.482
5. Tracks text	.162					.965	.256	.779
6. Uses dictionary	.839						.085*	.708
7. Comprehends (self-perception)	.277							.765
8. Has experience	.260							

*** p < .01 **p < .05 *p < .10

1—Based on students' response to questions on a 5 point scale where 1=strongly disagree and 5=strongly agree. Variables were rescaled so that an answer of "agree" or "strongly agree" = a positive response (1) and "neutral," "disagree" or "strongly disagree" = a negative response (0). Full statements from the student survey follow:

1. I enjoy reading for school
2. I am more productive when I use my laptop
3. I am distracted in class when I use my laptop
4. I read more slowly when the text is not in print
5. I usually use the mouse pointer, my finger, or another tool to follow the words when the text is in a digital format
6. I am more likely to look up words I don't know when the text is digital
7. I feel I comprehend more when the text is digital
8. I have used a laptop in school for more than two years

2—Based on all students who scored above the mean of 13 correct answers out of 24 on the two reading comprehension quizzes combined.

TABLE 3

Correlations between General Attitudes and Beliefs toward Reading (Pearson's Correlation Coefficient)

Variables[1]	*Enjoyment of reading print for pleasure*	*Enjoyment of reading digital for pleasure*	*Usefulness of laptop for schoolwork*	*Usefulness of laptop with reading assignments*
1. Enjoyment of reading assignments in school	.092	-.018	.230*	.304**
2. Enjoyment of reading print for pleasure		.325**	-.012	.025
3. Enjoyment of reading digital for pleasure			-.083	-.315**
4. Usefulness of laptop for schoolwork				.331**

** is significant at .01 level * is significant at .05 level

1—Based on students' response to questions on a 5 point scale where 1=strongly disagree and 5=strongly agree. Variables were rescaled so that an answer of "agree" or "strongly agree" = a positive response (1) and "neutral," "disagree" or "strongly disagree" = a negative response (0). Full statements from the student survey follow:

1. I enjoy the required reading I complete for school
2. I enjoy reading printed material for non-academic pursuits
3. I enjoy reading digital material for non-academic pursuits
4. I find using a laptop during the day to be helpful with schoolwork
5. I find using a laptop during the school day to be helpful with reading assignments in particular

TABLE 4

Correlations between General Attitudes and Beliefs toward Personal Laptop Usage (Pearson's Correlation Coefficient)

Variables[1]	*Schoolwork is more interesting*	*Understanding is better*	*Involvement is better*	*Production is better*	*Quality is better*	*Distractibility in class*	*Total Quiz Score*
1. Rather not use laptop	.325**	-0.12	-.288*	-.285*	-.318*	-.160	-.101
2. Schoolwork is more interesting		.546*	.550*	.330*	.347*	.098	.115
3. Understand school better			.535*	.547*	.483*	-.145	.158
4. More involved in school				.486*	.482*	-.171	.176
5. More productive in school					.433*	-.220*	.116
6. Quality of work is better						.005	.206*
7. Distracted in class							.088

** is significant at .01 level * is significant at .05 level

1—Based on students' response to questions on a 5 point scale where 1=strongly disagree and 5=strongly agree. Variables were rescaled so that an answer of "agree" or "strongly agree" = a positive response (1) and "neutral," "disagree" or "strongly disagree" = a negative response (0). Full statements from the student survey follow:

1. I would rather not use my laptop
2. Schoolwork is more interesting since we get to use our laptops
3. I understand schoolwork better when we use our laptops
4. I am more involved in school when I use my laptop
5. I am more productive when I use my laptop
6. The quality of my schoolwork is better as a result of my laptop
7. I am distracted in class as a result of my laptop

TABLE 6

Descriptive Statistics of Variables in the Study (Based on Performance on 24 Question Reading Comprehension Quiz)
With t scores in parentheses (difference in means vs. all students combined)

	Print Reading Group			Digital Reading Group			Combined Groups		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Dependent Variables									
All Students	13.10 (.345)	4.25	69	13.53 (.368)	3.84	66	13.31 (.000)	4.05	135
Cannon School	13.29 (.028)	4.12	41	13.85 (.768)	3.37	40	13.57 (.440)	4.45	81
Lausanne Collegiate School	12.82 (.576)	4.50	29	13.04 (.309)	4.49	26	12.93 (.599)	3.76	55
Boys	12.59 (.845)	3.99	27	13.50 (.229)	3.74	28	13.05 (.407)	3.86	55[1]
Girls	13.84 (.634)	4.79	31	13.11 (.234)	4.07	27	13.50 (.290)	4.46	58[1]
Students with < or = Two Years Laptop Experience	13.50 (.193)	4.52	20	13.42 (.177)	3.76	21	13.46 (.207)	4.10	41
Students with > Two Years Laptop Experience	13.13 (.240)	4.40	39	13.40 (.117)	4.05	35	13.18 (.219)	4.21	74
Students with Positive Attitude Toward Reading	17.25 (3.28)***	3.19	12	16.33 (2.53)**	2.74	12	16.69 (3.90)***	2.95	24
Students with Negative Attitude Toward Reading	12.32 (1.57)	3.94	58	13.02 (.440)	3.82	50	12.62 (1.34)	3.88	108
Students with High Comfort Level with Technology	14.20 (1.23)	3.97	40	13.63 (.445)	3.79	40	13.91 (1.07)	3.87	80
Students with Low Comfort Level With Technology	10.47 (2.73)***	3.94	17	12.47 (.761)	4.10	15	11.40 (2.40)**	4.08	32

TABLE 6 continued

Descriptive Statistics of Variables in the Study (Based on Performance on 24 Question Reading Comprehension Quiz)
With t scores (difference in means vs. all students)

	Print Reading Group			Digital Reading Group			Combined Groups		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Independent Variables—strong use of:									
Vocabulary Application$_2$	15.05 (2.39)**	3.85	39	14.83 (2.18)**	3.40	41	14.94 (2.96)***	3.61	80
Ability to Make Inferences$_2$	17.94 (4.45)***	2.74	16	17.58 (3.54)***	3.34	12	17.79 (5.55)***	2.96	28
Activation of Prior Knowledge$_2$	13.94 (.565)	5.47	16	14.86 (1.88)*	3.56	28	14.52 (1.69)*	4.31	44
Ability to Summarize and Synthesize Information$_2$	17.07 (4.65)***	2.45	27	16.75 (3.99)***	2.77	24	16.92 (5.92)***	2.58	51
Ability to Monitor and Self-Regulate	14.00 (.546)	3.76	11	13.86 (.348)	4.56	7	13.95 (.631)	3.96	18
Proactive Use of Resources While Reading	13.25 (.039)	5.50	8	11.62 (1.45)	3.50	13	12.24 (1.12)	4.31	21

*** p < .01 ** p < .05 * P < .10

1 – 18 students did not self-identify gender, 2 – mean for correct answers on questions = 75% or higher

FIGURE 1: School Attendance and Performance

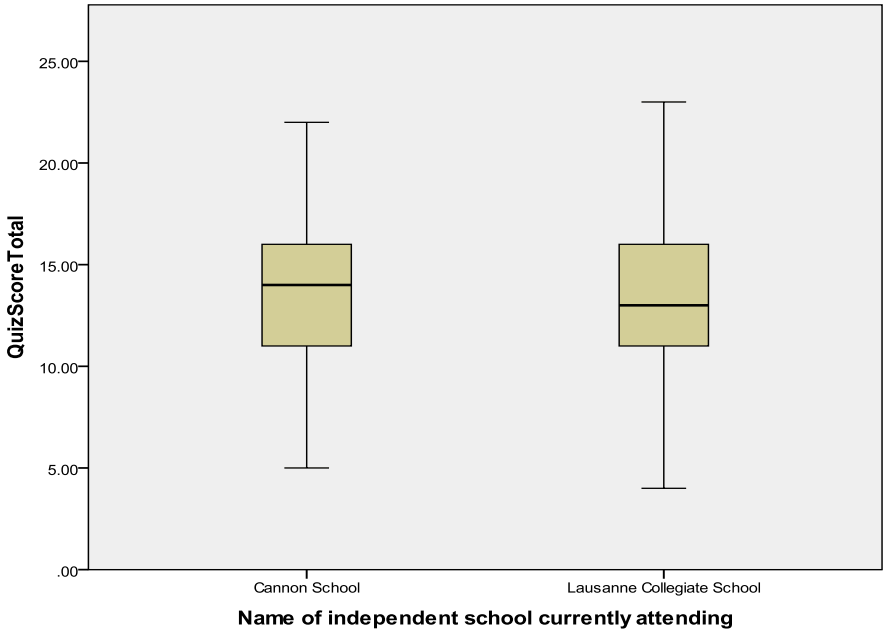


FIGURE 2: Gender and Performance

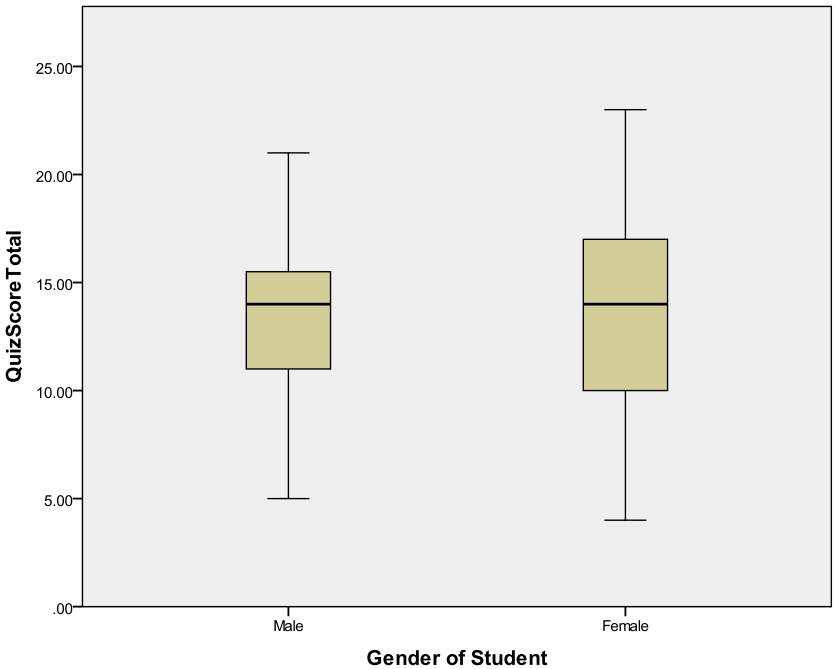


FIGURE 3: Differences in Means on Reading Comprehension Components

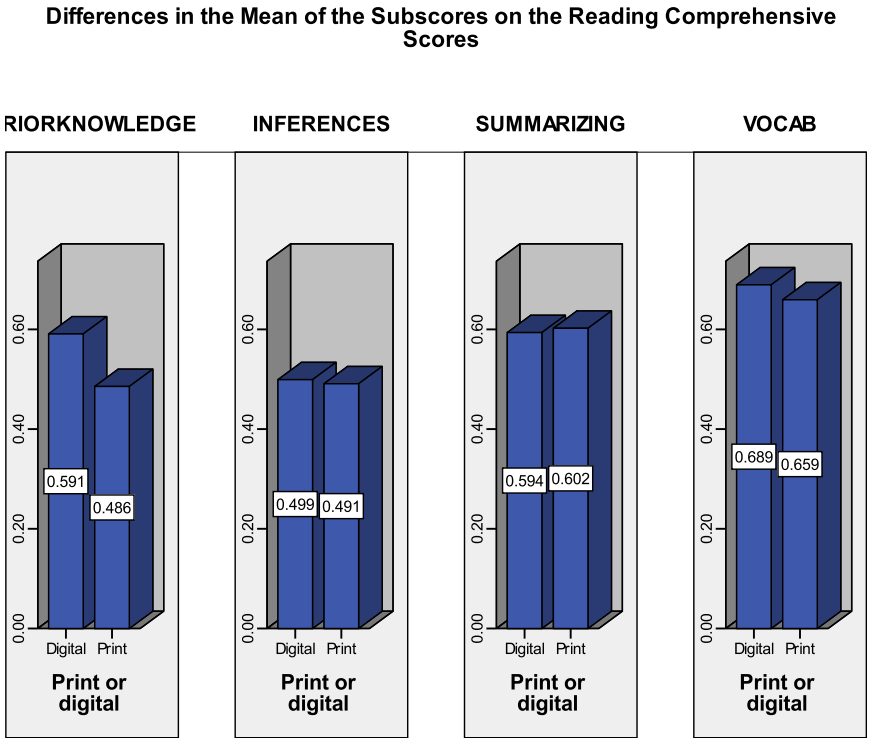


FIGURE 4: Self-monitoring

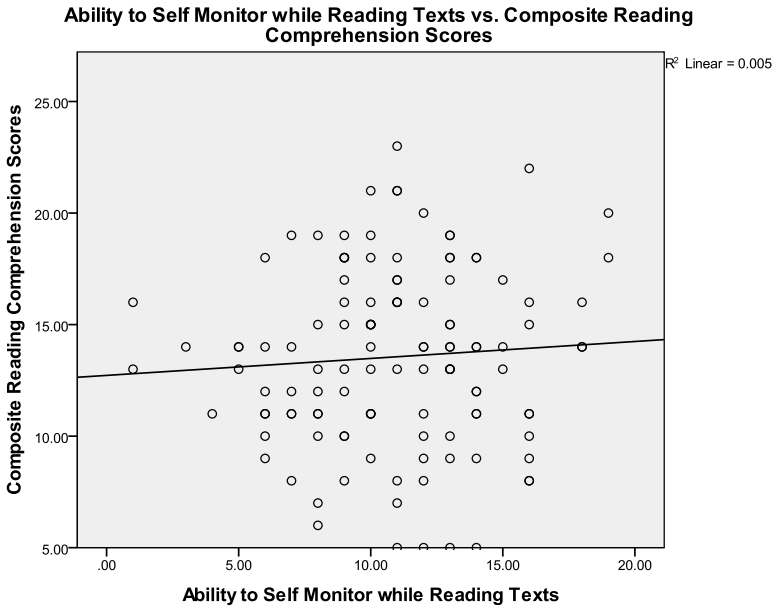


FIGURE 5: Self-monitoring by media type

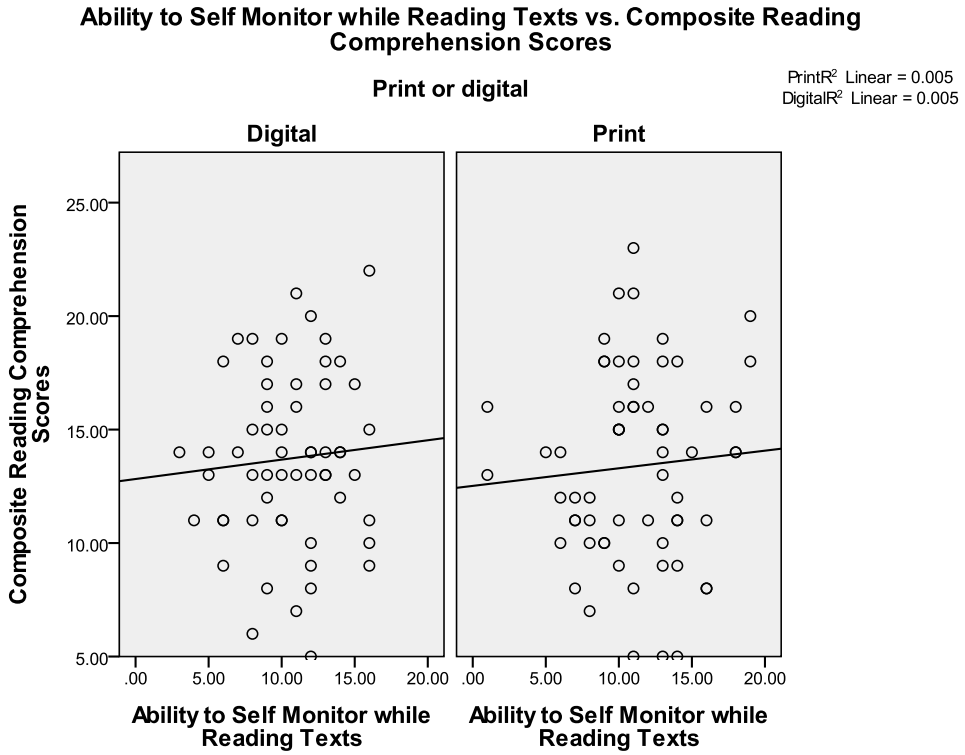


FIGURE 6: Comfort with Technology

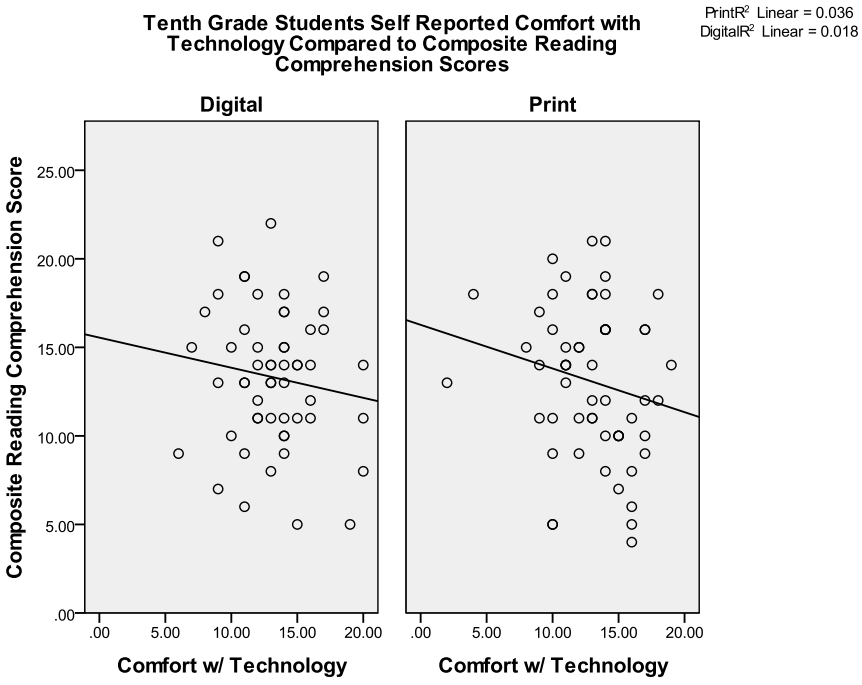
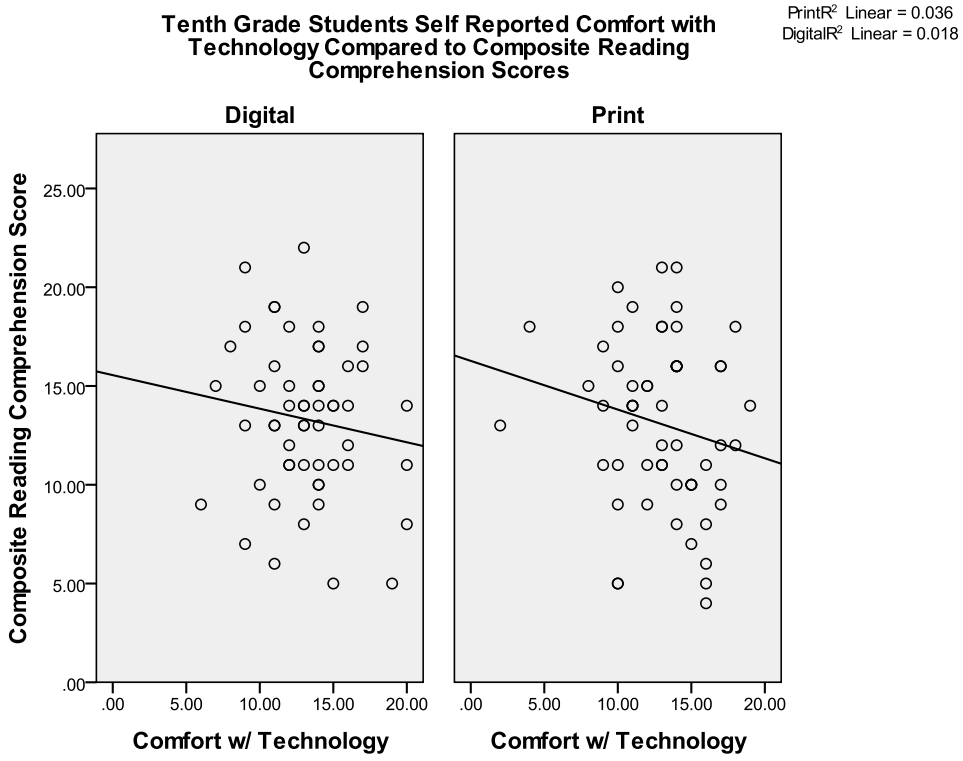


FIGURE 7: Reading Comfort and Total Quiz Score



APPENDIX A: Descriptive Data for Primary Variables

APPENDIX

Descriptive Statistics of Variables in the Study (based on performance on 24 question reading comprehension quiz)

	Print Reading Group			Digital Reading Group			Combined Groups		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Dependent Variables									
All Students	13.10	4.25	69	13.53	3.84	66	13.31	4.05	135
Cannon School	13.29	4.12	41	13.85	3.37	40	13.57	4.45	81
Lausanne Collegiate School	12.82	4.50	29	13.04	4.49	26	12.93	3.76	55
Boys	12.59	3.99	27	13.50	3.74	28	13.05	3.86	55_1
Girls	13.84	4.79	31	13.11	4.07	27	13.50	4.46	58_1
Students with < or = Two Years Laptop Experience	13.50	4.52	20	13.42	3.76	21	13.46	4.10	41
Students with > Two Years Laptop Experience	13.13	4.40	39	13.40	4.05	35	13.18	4.21	74
Students with Positive Attitude Toward Reading	17.25	3.19	12	16.33	2.74	12	16.69	2.95	24
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Independent Variables—strong use of:									
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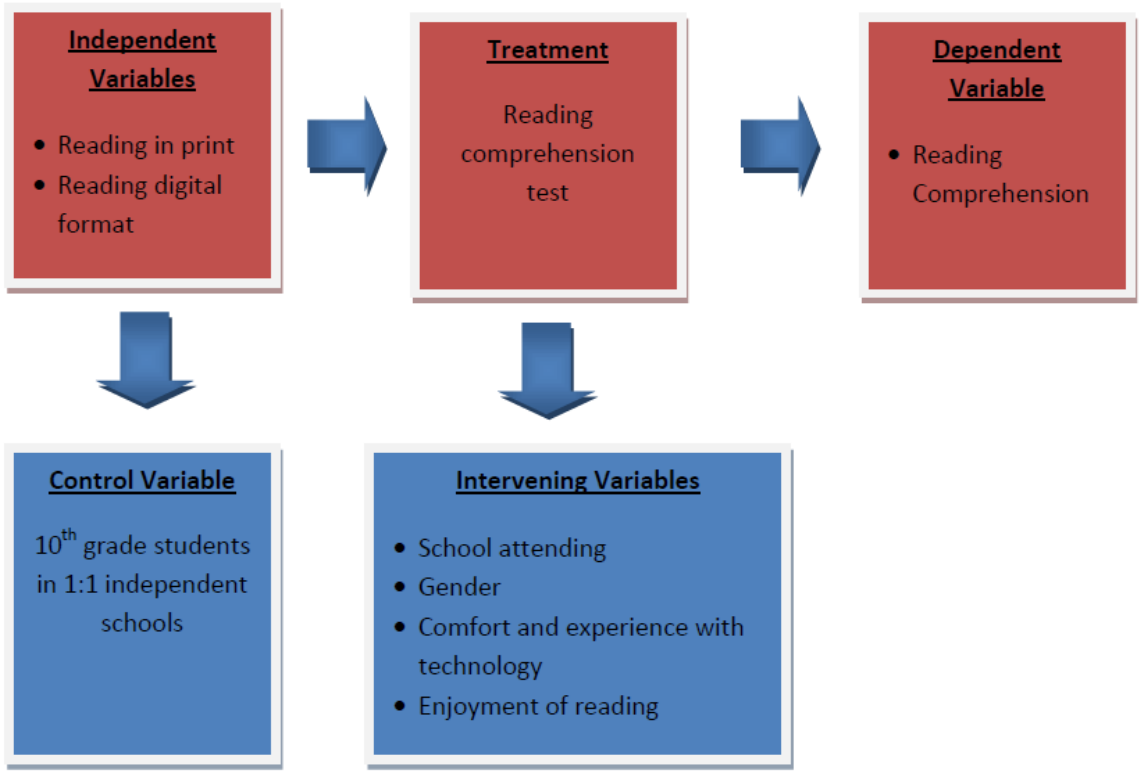
Ability to Summarize and Synthesize Information$_2$	17.07	2.45	27	16.75	2.77	24	16.92	2.58	51
Ability to Monitor and Self-Regulate	14.00	3.76	11	13.86	4.56	7	13.95	3.96	18
Proactive Use of Resources While Reading	13.25	5.50	8	11.62	3.50	13	12.24	4.31	21

1 – 18 students did not self-identify gender, 2 – mean for correct answers on questions = 75% or higher

APPENDIX B: Question Map



APPENDIX C: Aspects of the Research Question and Corresponding Survey Items

Research Question	**Survey Questions**
Reading Comprehension: Do students activate prior knowledge, make inferences, acquire vocabulary, and summarize and synthesize more when reading in print than online?	Reading Comprehension Quizzes 1 and 2 (all questions)
Reading Comprehension: Do students monitor and self-regulate their own reading more when reading in print than online?	Post-survey questions (Question 4, all components)
To what extent do history, comfort, and enjoyment of technology or reading effect reading comprehension when reading in print or online?	History (pre-survey 2, 3, 12, 14), Comfort (pre-survey 7, 11, 12, 13, 14, 15), Enjoyment (pre-survey 3-6, post-survey 15)