

Effect of Reading Modality on TNA Students' Reading Comprehension and Engagement

Caden Huffman

Mr. Jason Scott  
Math Senior Seminar  
May 2024

## **Abstract**

The purpose of this study was to investigate the differences between comprehension scores and engagement across reading modalities. Previous research found that digital reading can be effective if optimized for the screen, although paper was often found to be better. We hypothesized that the optimized digital exam would do the best in terms of comprehension. Also, the print copy would outperform the non-optimized digitized copy. Second, we hypothesized differences in engagement with the stories. A total of 34 high school students from The Neighborhood Academy participated in the study. All participants from the study were African American. The high school students each took 3 tests: a print copy, a digital copy, an optimized digital copy, and an engagement survey. First, we found that the paper reading test outperformed the non-optimized digital test. Secondly, there were no differences in engagement scores. Last, we found that there was a significant relationship between engagement scores and test scores regardless of modality. Our data suggests that students engaged with what they are learning is the best way for them to learn, understand, and comprehend the material, and paper assessments are likely still one of the best ways for students to show their comprehension.

In 2023, the College Board announced that the SAT is going all digital (1). Will this change in reading modality prove to be beneficial to the students? Schools are now introducing digital textbooks for 6-12, with 59% of teachers saying they are using e-books instead of traditional textbooks (2). However, research suggests many people may comprehend better on a print copy this can vary for some people (3). Reading modality may affect their comprehension, memorization, control strategies, mental representation, engagement, and the ability to multitask (3, 4, 5, 6, 7). This study will help teachers understand the best form of reading for students to maximize their potential. In this study, we had students take digital and print versions of similar reading tests and compare their comprehension scores and engagement.

### *Reading Comprehension and Modality*

Studying the effects of technology on reading comprehension is important because finding the most effective way of reading for students can help them comprehend better and succeed academically (4). Researchers conducted a study of 72 tenth graders on their reading comprehension. The tenth graders were broken into two groups: one was a group of students who read a digital pdf reading and the other group had a physical print copy of the reading. Afterward, both groups took a test on a computer. They hypothesized that technology will ultimately affect reading comprehension compared to a print copy (4). The results were in support of the hypothesis that computer screens lead to poorer reading comprehension scores. The reason the students on the computer scored lower may be because they had to jump and scroll around the screen, distracting them from the reading itself (4). This suggests that digital readings, when they do not allow for effective control strategies, may be inferior.

Presentation is an important factor when comprehension and memorization are valued (7). Another study also used 72 tenth and eleventh-graders and split them into two groups: One group was given a paper copy and the other group was given a computerized version of the same text, but it minimized scrolling and jumping between windows. Both groups were given tests, to test their reading comprehension and memorization from the reading. The researchers found no significant differences in memorization or comprehension. The researchers devised a way to make sure there was barely any difference between the digital and print copies (text structure, presentation on a single page, screen size) (7). So the students didn't need to scroll or zoom into the text, which may have led to better results. This agrees with prior research (4) that text control strategies and how the text is presented are key to making digital reading work.

One of the promises of digital modalities is the ability to make the text interactive, such as with a touchscreen. Researchers did a study with 72 preschool students and broke them into four groups within two categories. Category one: Group one experienced a paper story read aloud with no engaging questions. Group two had a paper story read aloud with varying engaging questions (low and high cognitive demand) (3). Category two: Group one is on a tablet where the story was read aloud. Group two is also on a tablet with the story read aloud with questions and more questions from a teacher. They measured vocabulary knowledge, engagement, and comprehension of the preschoolers. The researchers hypothesized that multimedia stories benefit children (3). The results were in support of the hypothesis for improving engagement and vocab retention when interacting with the iPad, but there was no effect on comprehension (3). This suggests touch-based devices are better for engagement and

vocabulary development in young students, but would this work for high school students who will not have the story read to them?

### *Electronic Media Use In Students*

Researchers studied the effect of reading modality on reading literacy skills in an international sample (5). This is different from reading comprehension; literacy skills encompass the ways students interact with the text to help them understand what they have read. Researchers used nearly thirty-two thousand students from nineteen different countries who took a standardized reading test called the PISA 2009 (Programme for International Student Assessment). They were randomly split into two groups. One group had an electronic reading format and the other group had a print reading format. Both groups were tested on five different subjects: reading literacy, online reading activities, use of cognitive strategies, knowledge of metacognitive strategies, and navigation strategies. They hypothesized that electronic reading would have worse results compared to a print copy. The results were in support of the hypothesis, the students with the print copy overall did better. This study helped us realize that control strategies and mental representation are important for a reader and that students tend to perform these skills better on a print version of a test.

When students use digital media to learn, they are often faced with notifications and alerts from other apps and services, which can force multitasking (6). Multitasking can serve as a distraction especially when off topic. Researchers want to know the impact on learning if a student were to multitask in a learning environment. Their study used 122 Turkish undergraduate students split into three groups: Group One had no devices and did paper and pen notes in a lecture, Group Two had their phones and were able to send and receive text messages, Group Three had no phones but had their laptop/tablet devices and scrolled through social media (6). The researchers hypothesized that multitasking has a negative effect on academic performance (6). These three groups took a test and the results supported the hypothesis that multitasking lowered academic achievement. In a high school environment such multitasking may not be permitted in a test but students may do it anyway for example, on an iPad. Some of the reading modality may be due to some of the distractions instead of the screen itself.

Overall, the research says that technology affects engagement, reading literacy skills, reading comprehension, cognitive strategies, and our ability to multitask. The results of these studies are varied, some find benefits with paper and others find screens more beneficial. This study will build on the previous research offering a more current understanding, due to our shifting towards a more digital age after Covid in 2020. Therefore this study will primarily build on the factors that affect students when reading on a digital device to see if it will hinder their ability to comprehend text. We presented TNA high school students with 3 different tests in a repeated measures design. One test was a paper exam, one was a digital version identical to the paper print copy, and the third was a digital test optimized around the screen to minimize scrolling. Also, we will survey the students on how interested/engaged they were with each test.

First, we hypothesized that the optimized digital exam would do the best in terms of comprehension. This is because research says minimizing scrolling and the need to move around the screen will produce better results (7). Also, the print copy will outperform the

digitized copy, because they will have better control strategies on a print copy (4, 5). Second, we hypothesize that there will be differences in engagement with the stories, with no direction specified, as the only research on engagement focused on preschoolers and interactive text (3).

## Method

A total of 34 high school students from The Neighborhood Academy participated in the study. All participants from the study were African American, composed of males (53%) and females (47%) from grades 10 and 11 and between the ages of 16-18. These groups of students were picked because they will have to take the SAT so asking them to do these tasks is academically appropriate.

We planned to start by finding SAT practice tests and giving them to a small group ( $n=5$ ) of other students not in the study to see if they were similar (8). All three were nonfiction and had 10 questions accompanying them. The passage from test number two was about ethical economics and had an average score of 4.4. The next passage was from test number 4 and was about a volcano and had an average of 6. Last, the passage from test number 10 was about imperialism and had an average of 2.4. This passage was very low and deemed inadequate. We decided to replace it with a passage from test three; this passage was about the impact of automobiles. This was not tested, due to time constraints, but a teacher reviewed it and agreed it was adequate and similar to the others.

Next, we asked teachers to use some of their class time to experiment and they gave the students a point incentive to try their best. When we entered the class, the purpose was explained and students were given one of three tests: a paper copy, a digital copy, and a digital optimized copy. Students had 15 minutes to finish and we then returned two other days that week to give the other tests.

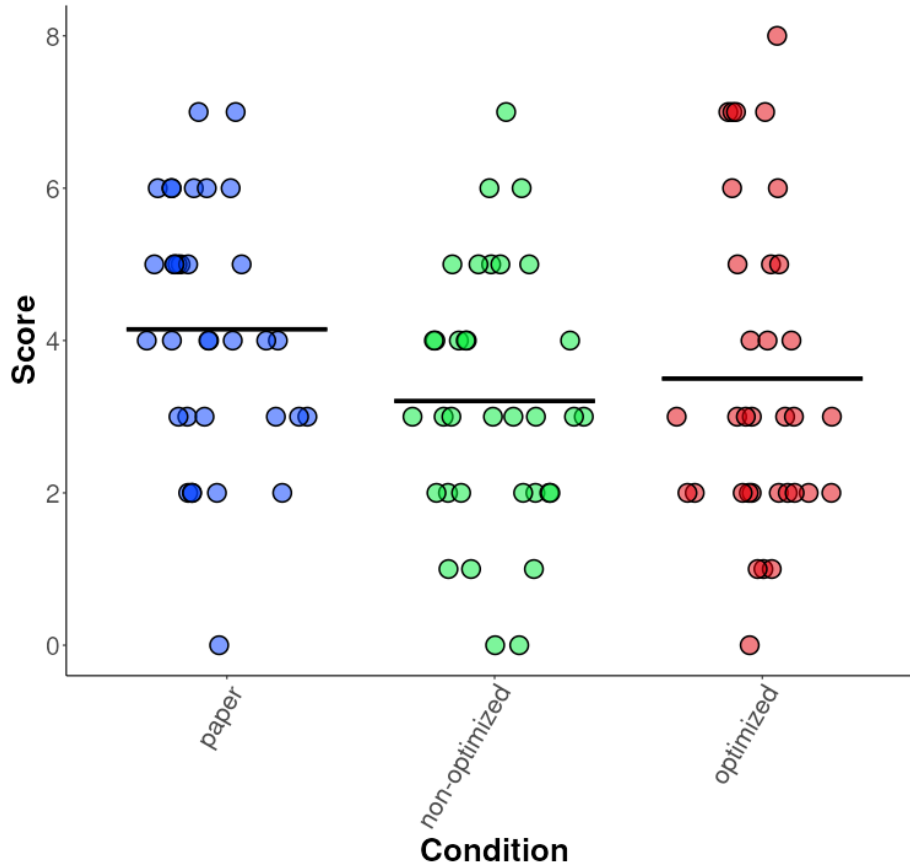
The optimized copy was presented on Google Slides. First, they saw the entire reading. Then each slide had a question, with the relevant part of the text that applied to the question inserted next to it. The digital copy was just a pdf scan of the paper. Students would have to zoom and scroll to read and see questions. The answer sheets had a space for the name, a space to answer the questions, and a short engagement survey about the text. The engagement questions were written by the investigators and had a 1-10 agreement scale. The responses were added up to give a total of 40.

Differences in quiz performance and the engagement of the test were calculated using a one-way ANOVA test for correlated samples. Individual differences were found using a Tukey post-hoc test. Relationships between engagement and performance were calculated with a Pearson r-test. The abbreviation M is the mean, and SD is the standard deviation. All tests were calculated using [vassarstats.net](http://vassarstats.net) with a 0.05 significant threshold.

## Results

We expected to find that the digitally optimized test would have better performance than the digitally non-optimized test. We experimented with 34 students in the 10th and the 11th grade. They took three different tests and we compared them to themselves. We also had them take an engagement survey at the end of each test. Each test was presented in either paper form, a digitized version of the paper, or a digital test optimized for the screen to reduce scrolling.

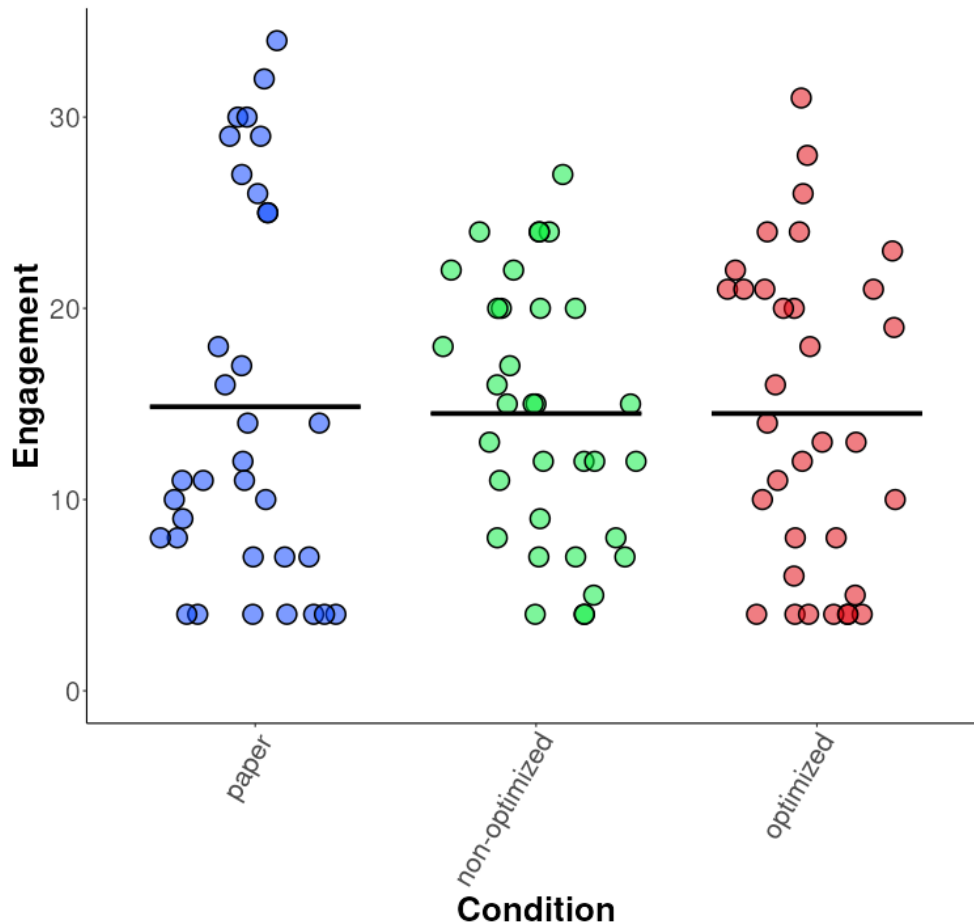
First, we graded the scores from all the students and used a one-way ANOVA with correlated samples to examine differences ( $F(2, 66)=3.27, p=0.04$ ). We found, using a Tukey HSD post-hoc test, that the paper copy ( $M=4.1, SD=1.7$ ) did better than the non-optimized digital copy ( $M=3.2, SD=1.7$ ). There were no significant differences between the optimized copy to the paper copy, and the optimized copy ( $M=3.5, SD=2.1$ ) to the non-optimized copy. Therefore, this suggests that students do their best on a paper copy of a reading test.



**Figure 1. The paper reading test outperformed the non-optimized digital test.**

Dot plot showing the mean reading score for each condition: paper, non-optimized, and optimized ( $n=34$ ). The scores came from a practice SAT tests for each condition, which all had ten questions that were graded. One-way ANOVA for correlated samples with Tukey post-hoc test,  $p=0.04$ .

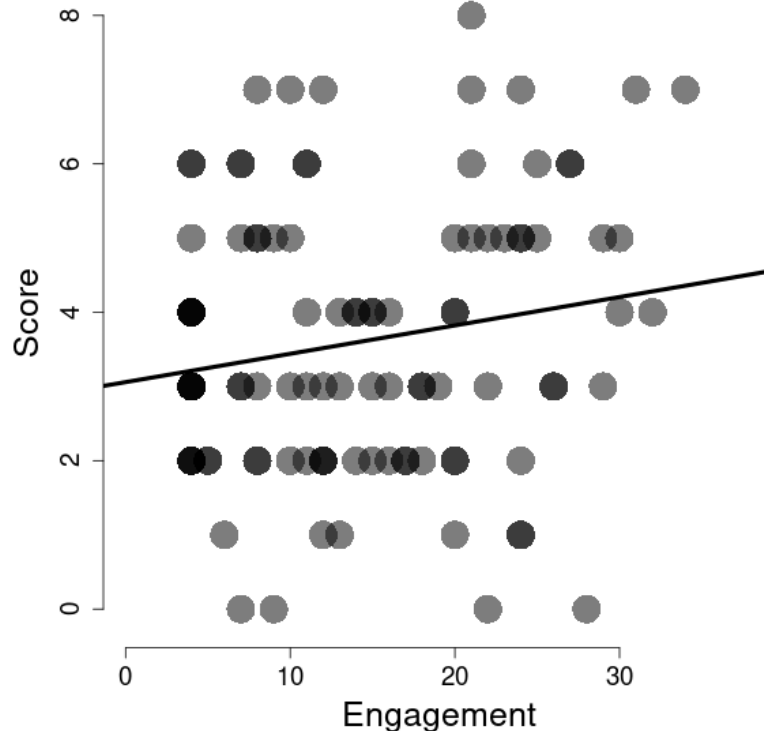
Secondly, we totaled the surveys from all the students and used a one-way ANOVA with correlated samples to examine differences ( $F(2, 66)=3.27, p= 0.96$ ). We found that the engagement scores of the paper copy ( $M=14.9, SD=9.9$ ) did insignificantly better than both the non-optimized digital copy ( $M=14.5 SD=6.7$ ) and the optimized copy ( $M=14.5 SD=8.2$ ) to the non-optimized copy. Overall there was no difference in engagement scores between the three copies (**Figure 2**).



**Figure 2. All the engagement scores were insignificant to one another.**

Dot plot showing the mean engagement score for each condition: paper, non-optimized, and optimized ( $n=34$ ). The scores came from a survey created for engagement for each condition, which all had ten questions that were graded. One-way ANOVA for correlated samples with Tukey post-hoc test,  $p= 0.96$ .

While there were no differences in engagement we were curious if there was a relationship between engagement scores and reading scores. This poses the question, do more engaged people score better? An r-test found a positive significant relationship between the engagement scores and reading scores ( $r = 0.17$ ,  $p = 0.04$ ). In general, the more engaged you are the higher you can score, regardless of the type of test you took. It looks like engagement is the function of the person's preference and not one type of modality or another.



**Figure 3. Significant relationship between engagement scores and test scores.** A Scatterplot showing the correlation of having more engagement tends to increase the test scores ( $n=34$ ). The engagement scores ( $min=4$ ,  $max=40$ ) were derived from a survey and the test scores came from practice SAT tests.  $r$ -test,  $p < 0.05$ .

## Discussion

In this study, we examined the differences in performance when students experience different modalities of a test. Our first hypothesis was that modality would be related to reading comprehension. However, we expected students to do best on the optimized digital copy and that the paper copy would do better than the non-optimized copy. This hypothesis is partially supported because there was a difference in modality, but the paper copy did the best, with no differences in digital copies (**Figure 1**). Our second hypothesis was there would be differences in engagement with the stories, with no direction specified (**Figure 2**). This hypothesis was not supported because there were no significant differences between engagement and the scores of each modality. However, more engaged students did score higher.



Our results were consistent with another study by Jiun-yu Wu. Jiun-yu found that electronic reading would have worse results compared to a print copy (5). Our study also found that students would do better on a paper copy than on an unoptimized copy (**Figure 1**). Universally students tend to do better on paper copies because students may have had paper familiarized throughout the whole time they were in school. Also, paper modality allows for control strategies where readers can easily reread or flip back and forth.

Similar to Jiun-yu, Mangen found that computer screens lead to poorer reading comprehension scores for students (4). We found that the majority of students tend to score higher on paper. Although students tend to score higher on a paper copy we learned that the score and engagement correlated with one another so students could potentially score higher on computers if they were more engaged with it. Importantly, the paper test was not found to be more engaging, so it is not clear if more engaging screens are the answer.

Our results were inconsistent with another study by Zhou et al. They found that multimedia stories help pre-schools improve engagement and vocab retention when interacting with the iPad, but there was no effect on comprehension. We found that students didn't have any differences in their engagement for each of the modalities, but we also found that students who are more engaged can score higher (**Figure 2&3**). This means students who are more engaged have the potential to score higher, because they may be able to take in more information than being disinterested and not absorbing information. In our study, the digital tests were not made to be intentionally more engaging, so that might explain why these digital tests did not do as well.

Future researchers could consider making the digital test more engaging and possibly interactive because our study has found that students who had higher engagement scores tended to have better comprehension scores (**Figure 3**). We also suggest that if a student primarily used technology to learn instead of using paper their comprehension scores would be higher compared to using a print copy. If a student was taught to use technology for example a tablet or a computer to have that as their native learning it would become the new paper, because schools in general primarily used paper pre-COVID and we were all reading and working on paper so we learned to get used to it. So if technology were the same way how much more could we get done? Investigating the modalities students are normally taught in might be an important factor in this topic.

Our study had limitations. Our first limitation was that we didn't have time to do a dry run for a replacement reading because one of the PSATs wasn't as similar to the others. Therefore, we are not sure if it was similar in difficulty. We also could have had more students participate in this study, but school schedules prevented us from getting both 11th-grade classes. This situation was outside of our control because their teachers had a schedule up until right before the deadline of this study.

According to our research, engagement is an important factor for the retention of information. A more engaged student is capable of absorbing information and they would be able to do their work and take tests better. Therefore it would be best if teachers could try to choose texts that are more engaging for their students who may struggle with their classes. The bottom line is that trying to keep students engaged with what they are learning is the best way

for them to learn, understand, and comprehend the material. Also, schools should not completely give up on paper tasks, as they produce the highest scores.

## Works Cited

1. "Digital SAT – SAT Suite | College Board." SAT Suite of Assessments, <https://satsuite.collegeboard.org/digital>. Accessed 28 November 2023.
2. Mouhanna, Alecia. "New survey highlights increased ebook usage by schools amid COVID-19." 27 October 2020, <https://company.overdrive.com/2020/10/27/new-survey-highlights-increased-ebook-usage-by-schools-amid-covid-19/>. Accessed 28 November 2023.
3. Yadav, Aman, and Ninger Zhou. "Effects of multimedia story reading and questioning on preschoolers' vocabulary learning, story comprehension and reading engagement." *Educational Technology Research and Development*, 2017, <http://dx.doi.org/10.1007/s11423-017-9533-2>.
4. Mangen, Anne, and Bente R. Walgermo. "Reading linear texts on paper versus computer screen: Effects on reading comprehension." *International Journal of Educational Research*, vol. 58, 2013, pp. 61-68.
5. Wu, Jiun yu, and Ya-Chun Peng. "The modality effect on reading literacy: perspectives from students' online reading habits, cognitive and metacognitive strategies, and web navigation skills across regions." *Interactive Learning Environments*, 2016, <https://doi.org/10.1080/10494820.2016.1224251>.
6. Talan, Tarik, and Muhammet Demirbilek. "Active Learning in Higher Education." *The effect of social media multitasking on classroom performance*, vol. 1, no. 13, 2017.
7. Aparicio, Xavier, et al. "Science Direct." *The impact of paper-based versus computerized presentation on text comprehension and memorization*, vol. 54, 2016, pp. 569-576.
8. "Full-Length Linear SAT Practice Tests (Nonadaptive) – SAT Suite." SAT Suite of Assessments, <https://satsuite.collegeboard.org/sat/practice-preparation/practice-tests/linear>. Accessed 10 April 2024.