

# Reading Comprehension Levels in Hard Copy vs. iPad Format



AP Statistics  
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## **I. Introduction**

Some people in our society are resistant to the use of technology in the classroom, but at our school, we try to embrace it. Each student and teacher is given an iPad and certain activities are done using the device. Also, all assignments are posted on an app called Schoology, so the concept of using an agenda is taken out of student's education. Many students have embraced the introduction of technology into the school setting. However, some teachers and students are not pleased with some of the effects of technology and disagree with others on how much it should be implemented in the school setting.

We decided to specifically look at if reading information from the iPad is negatively affecting student's comprehension when reading. Our research question is: Is there a difference in comprehension of content when a passage is read on the iPad vs. when it is read on the traditional hard-copy format? We believe that there will be a significant difference in understanding depth of content when a passage is read on the iPad vs. when it is read in traditional hard-copy format. We believe that students will more fully comprehend what they are reading when it is read from the traditional hard copy format than when it is read from the iPad because there are more distractions on an iPad. We are accustomed to skimming on electronic devices vs reading paper.

## **II. Background Research**

When students are asked to do an assignment on schoology, some ask to have a paper copy because they find it easier than using technology. "Apple finds the education market an important area of growth for their products"(James, 2015). Technology promotes more interaction with the class, more organization, and saving paper, which helps save the environment, but does it make children's comprehension skills suffer? Ferris Jabr argues that paper still has its advantages over screens. His arguments involve some experiments, polls, and consumer reports that suggest "screen reading drains more mental resources while people are reading, making it harder for them to remember what they have just read"(James, 2015). Later on in the article, James states that Jabr didn't do a proper study, because he only did this experiment on two people and then made the conclusion. "Another study carried out by Anne Mangen and her colleagues at the Reading Centre of the University of Stavanger recorded seventy two randomly selected tenth graders reading and vocabulary skills. They were then split into two groups. The first group read two passages on the computer, and the other group read two in regular text form. Then they both answered questions and their comprehension skills were scored from those questions. The results clearly showed that those who had read on computer screens had understood less than those who read on paper. Mangen states that it is easier for the brain when you can touch as well as see. Another study that she completed concluded that students who read on paper are more deeply involved in the story than those who used the iPads" (Christensen). With schools getting involved in new technological advancements, we tested this claim to see if the money put into the iPad program for the 1:1 student to teacher ratio is worth it or if it causing some students to suffer due to comprehension difficulties.

## **III. Experimental Design and Procedure**

We conducted our experiment by using a matched pairs design, meaning that we had the subjects read one passage (fossil passage or literature passage) on each material (iPad and hard-copy format) and then take the corresponding test to which passage they just read. We

administered the treatments to 32 students at our schools who were in tenth grade or higher and were willing to participate in our experiment. We asked students who were in study halls to take part in our experiment and we also got permission from two teachers who allowed us to collect data from all of an English and most of a Bible class. We randomly assigned each student the material they read from first and the passage that they read first by having each student who participated in the experiment select a piece of paper from a container where there were originally 32 slips of paper labeled with an A, B, C, or D. Once a piece of paper was selected from the container, it was not replaced, meaning that we had eight students that were in tenth grade or higher in each of the four treatment groups. Also, every time a piece of paper was selected from the container, the slips of paper were be mixed thoroughly before the next student chose their letter. Treatment A was when the student read the fossil passage first on the iPad. Treatment B was when the student read the fossil passage first in the hard-copy format. Treatment C was when the student read the literature passage first on the iPad and treatment D was when the student read the literature passage first in the hard-copy format.

Which passage and reading material will be used first in our experiment

	iPad Version	Hard Copy Version
Fossil Passage	Treatment A	Treatment B
Literature Passage	Treatment C	Treatment D

Once each student had their treatment randomly assigned to them, they were given their first reading passage and an answer sheet that was on a separate piece of paper. The students had a total of twelve minutes to read the passage and answer the eight questions that corresponded to the passage on the answer sheet that was given to them. Once the twelve minutes were up, the passage and questions were taken away from the students, leaving them only with their answer sheet. The student then read the passage that they had not yet read and read it on the material that they had not yet read from and then answered the eight questions that pertained to that passage. Again, the students had a total of twelve minutes to both read the passage and to answer all of the questions on the answer sheet that was given to them. Once the twelve minutes had passed, the passages and questions were collected from the students and the students were instructed to fill out the general student questionnaire, which was at the bottom of their answer sheet. The questions that were on this questionnaire pertained to the student's grade, gender, English class level, and native language. Both eight question quizzes were graded by one of the group members that administered the treatments to the students and the number of correct answers on each quiz was recorded. Once we had all of our data, we found the difference of the two scores, hard copy score - iPad score, for each participant and used this difference to see if the material on which they read the passage had any effect on their understanding of the depth of content.

#### **IV. Script and Passages Used**

This is the script we read when we administered the treatments to our subjects.

Today, you are going to be reading two passages and taking two quizzes that test your reading comprehension skills. First, we will distribute a piece of paper that will be passed from student to student and you will write your name and Christopher Dock email address on it when you receive it. Then, we will walk around the room with a container of slips of paper that have the letters A through D on them and each person will choose a letter from the container without looking. The letter you will choose represents which passage you will be reading first and on which material you will be reading the passage on. You will also be given an answer sheet where you will write the answers to the questions for each passage you read and answers to the general student questionnaire.

(After that was read, we handed out answer sheets, had the paper with names and email addresses on it passed to every student, and had each student pick their treatment letter from the container without looking)

Now that you have selected your letter, please circle that letter on the answer sheet that was given to you where the words "treatment letter" is written. We are now going to call out each treatment letter, and if you have that treatment letter, please raise your hand so we can give you or send you the materials you need for the first part of the experiment. Anyone who is in treatment group A and C will be sent an email containing the passage that corresponds to their certain treatment group. So if you are in one of those groups, please check your email and open the document when I say "start". Anyone who is in treatment group B and D will have a packet containing three papers placed face down on their desk. So, if you are in one of those groups, do not touch or flip over the packet of papers until I say "start".

(After that was read, we emailed the correct passage and questions to the students who were in treatment groups A and C and distributed the correct passage and questions to the students who were in treatment groups B and D)

When I say "start", you will have twelve minutes to read the passage and answer the questions that pertained to that specific passage while using the passage as a reference. When you have completed reading the passage and answering the questions, please sit quietly until we give more instructions. Also, please circle on your answer sheet which passage you read and if you read it on the iPad or the hard copy format.

(After that was read, we said "start", began the timer that was counting the twelve minutes of test taking and made observations about our test subjects. Once the twelve minutes were up, the passage and questions were taken away from the students if it was in the hard copy format and if it is on the iPad, we asked the students to close out of the document and put their iPads in their backpacks)

Now we will begin the second part of our experiment. Again, I will call out each treatment letter and if you have that treatment letter, please raise your hand so we can give you or send you the

materials that you will need. What you will be receiving is the passage that you have not read yet and its corresponding questions and you will read it on material that you have not read from yet.

(After that was read, we emailed the correct passage and questions to the students who were in treatment groups B and D and distributed the correct passage and questions to the students who were in treatment groups A and C)

Again, when I say "start", you will have twelve minutes to read the passage and answer the questions that pertained to that specific passage while using the passage as a reference. Please circle on your answer sheet which passage you read and if you read it on the iPad or the hard copy format. When you have completed reading the passage and answering the questions, please remain quiet and complete the general student questionnaire that is at the bottom of your answer sheet.

(After that was read, we said "Start", began the timer that counted the twelve minutes of test taking, and made observations about our test subjects. Once all of the students were done reading, answering the questions that pertained to their passage and completed the general student questionnaire, we took away their passage packets if they had a hard copy of their passage or instructed them to close out of the passage document and to put their iPads in their backpacks)

As mentioned on the bottom of your answer sheet, please do not discuss the passages, the quiz questions, or answers with anyone until we have concluded our experiment.

### **Fossil Passage**

This is the passage that the students who volunteer to take part in our experiment will read and answer the ten corresponding questions first if they are in treatment groups A or B

The fossil remain of the first flying vertebrates, the pterosaurs, have intrigued paleontologists for more than two centuries. How such large creatures, which weighed in some cases as much as a piloted hang glider and had wingspans from 8 to 12 meters, solved the problems of powered flight, and exactly what these creatures were-reptiles or birds- are among the questions scientist have puzzled over. Perhaps the least controversial assertion about the pterosaurs is that they were reptiles. Their skulls, pelvises, and hind feet are reptilian. The anatomy of their wings suggests that they did not evolve into the class of birds. In pterosaurs a greatly elongated fourth finger of each forelimb supported a wing like membrane. The other fingers were short and reptilian, with sharp claws, In birds the second finger is the principle strut of the wing, which consists primarily of features. If the pterosaur walked or remained stationary, the fourth finger, and with it the wing, could only turn upward in an extended inverted V-shape along side of the animal's body. The pterosaurs resembled both birds and bats in their overall structure and proportions. This is not surprising because the design of any flying vertebrate is subject to aerodynamic constraints. Both the pterosaurs and the birds have hollow bones, a feature that represents a saving in weight. In the birds, however, these bones are reinforced more massively by internal struts. Although scales typically cover reptiles, the pterosaurs probably had hairy coats. T.H. Huxley reasoned that flying vertebrates must have been warm – blooded

because flying implies a high internal temperature. Huxley speculated that a coat of hair would insulate against loss of body heat and might streamline the body to reduce drag in flight. The recent discovery of a pterosaur specimen covered in long, dense, and relatively thick hairlike fossil material was the first clear evidence that his reasoning was correct. Efforts to explain how the pterosaurs became airborne have led to suggestions that they launched themselves by jumping from cliffs, by dropping from trees, or even by rising into light winds from the crests of waves. Each hypothesis has its difficulties. The first wrongly assumes that the pterosaur's hind feet resembled a bat's and could serve as hooks by which the animal could hang in preparation for flight. The second hypothesis seems unlikely because large pterosaurs could not have landed in trees without damaging their wings. The birds call for high waves to channels updrafts. The wind that made such waves however, might have been too strong for the pterosaurs to control their flight once airborne.

1. Who reasoned that flying vertebrates must have been warm-blooded?

- A. Steve Irwin
- B. Bill Nye
- C. T. H. Huxley
- D. John Homer
- E. Robert Baker

Correct Answer : C

2. What is the approximate wingspan of a pterosaur?

- A. 4 to 6 meters
- B. 8 to 14 meters
- C. 6 to 10 meters
- D. 8 to 12 meters
- E. 12 to 14 meters

Correct Answer : D

3. It can be inferred from the passage that scientists now generally agree that the

- A. enormous wingspan of the pterosaurs enable them to fly great distances
- B. structure of the skeleton of the pterosaurs suggests a close evolutionary relationship to bats
- C. fossil remains of the pterosaurs reveal how they solved the problem of powered flight
- D. pterosaurs were reptiles
- E. pterosaurs walked on all fours.

Correct Answer : D

4. The authors views the idea that the pterosaurs became airborne by rising into light winds created by waves as

- A. revolutionary
- B. unlikely

- C. unassailable
- D. probable
- E. outdated

Correct Answer : B

5. According to the passage, the skeleton of a pterosaur can be distinguished from that of a bird by the

- A. size of its wingspan
- B. presence of hollow spaces in its bones
- C. anatomic origin of its wing strut
- D. presence of hook like projections on its hind feet
- E. location of the shoulder joint joining the wing to its body

Correct Answer : C

6. The ideas attributed to T.H. Huxley in the passage suggest that he would most likely agree with which of the following statements?

- A. An animal's brain size has little bearing on its ability to master complex behaviors.
- B. An animal's appearance changes dramatically over a period of time.
- C. Animals within a given family group are unlikely to change their appearance
- D. The origin of flight in vertebrates was an accidental development rather than the outcome
- E. The pterosaurs should be classified as birds, not reptiles.

Correct Answer : B

7. It can be inferred from the passage that which of the following is a characteristic of the pterosaurs?

- A. They were unable to fold their wings when not in use.
- B. They hung upside down from branches as bats do before flight
- C. They flew in order to capture prey
- D. They were an early stage in the evolution of the birds
- E. They lived primarily in a forest like habitat.

Correct Answer : A

8. It can be inferred from the passage that some scientists believe that pterosaurs

- A. lived near large bodies of water
- B. had sharp teeth for tearing food
- C. were attacked and eaten by larger reptiles
- D. had longer tails than many birds
- E. consumed twice their weight daily to maintain their body temperature

Correct Answer : A



**Literature Passage**

This is the passage that students who volunteer to take part in our experiment will read and answer the ten corresponding questions first if they are in treatment groups C and D.

Those examples of poetic justice that occur in medieval and Elizabethan literature, and that seem so satisfying, have encouraged a whole school of twentieth-century scholars to "find" further examples. In fact, these scholars have merely forced victimized character into a moral framework by which the injustices inflicted on them are, somehow or other, justified. Such scholars deny that the sufferers in a tragedy are innocent; they blame the victims themselves for their tragic fates. Any misdoing is enough to subject a character to critical whips. Thus, there are long essays about the misdemeanors of Webster's Duchess of Malfi, who defied her brothers, and the behavior of Shakespeare's Desdemona, who disobeyed her father. Yet it should be remembered that the Renaissance writer Matteo Bandello strongly protests the injustice of the severe penalties issued to women for acts of disobedience that men could, and did, commit with virtual impunity. And Shakespeare, Chaucer, and Webster often enlist their readers on the side of their tragic heroines by describing injustices so cruel that readers cannot but join in protest. By portraying Griselda, in the Clerk's Tale, as a meek, gentle victim who does not criticize, much less rebel against the prosecutor, her husband Walter, Chaucer incites readers to espouse Griselda's cause against Walter's oppression. Thus, efforts to supply historical and theological rationalization for Walter's persecutions tend to turn Chaucer's fable upside down, to deny its most obvious effect on reader's sympathies. Similarly, to assert that Webster's Duchess deserved torture and death because she chose to marry the man she loved and to bear their children is, in effect to join forces with her tyrannical brothers, and so to confound the operation of poetic justice, of which readers should approve, with precisely those examples of social injustice that Webster does everything in his power to make readers condemn. Indeed, Webster has his heroin so heroically lead the resistance to tyranny that she may well inspire members of the audience to imaginatively join forces with her against the cruelty and hypocritical morality of her brothers. Thus Chaucer and Webster, in their different ways, attack injustice, argue on behalf of the victims, and prosecute the persecutors. Their readers serve them as a court of appeal that remains free to rule, as the evidence requires, and as common humanity requires, in favor of the innocent and injured parties. For, to paraphrase the noted eighteenth-century scholar, Samuel Johnson, despite all the refinements of subtlety and the dogmatism of learning, it is by the common sense and compassion of readers who are uncorrupted by the characters and situations in medieval and Elizabethan literature, as in any other literature, can best be judged.

1. Which tale from *The Canterbury Tales* was mentioned in this passage?

- A. The Wife of Bath's Tale
- B. The Clerk's Tale
- C. The Miller's Tale
- D. The Parson's Tale
- E. The Physician's Tale

Correct Answer : B

2. Which famous writer was not mentioned in this passage?

- A. Shakespeare
- B. Chaucer
- C. Bandello
- D. Webster
- E. Dickens

Correct Answer : E

3. According to the passage, some twentieth-century scholars have written at length about

- A. Walter's persecution of his wife in Chaucer's the Clerk's Tale
- B. the Duchess of Malfi's love for her husband
- C. the tyrannical behavior of the Duchess of Malfi's brothers
- D. the actions taken by Shakespeare's Desdemona
- E. the injustices suffered by Chaucer's Griselda

Correct Answer : D

4. The primary purpose of the passage is to

- A. describe the role of the tragic heroine in medieval and Elizabethan literature
- B. resolve a controversy over the meaning of "poetic justice" as it is discussed in certain medieval and Elizabethan literary treatises
- C. present evidence to support the view that characters in medieval and Elizabethan tragedies are to blame for their fates
- D. assert that it is impossible for twentieth-century readers to fully comprehend the characters and situations in medieval and Elizabethan literary works
- E. argue that some twentieth-century scholars have misapplied the concept of "poetic justice" in analyzing certain medieval and Elizabethan literary works.

Correct Answer : E

5. It can be inferred from the passage that the author consider Chaucer's Griselda to be

- A. an innocent victim
- B. a sympathetic judge
- C. an imprudent person
- D. a strong individual
- E. a rebellious daughters

Correct Answer : A

6. The author's tone in her discussion of the conclusions reached by the "school of twentieth-century scholars" (line 4) is best described as

- A. plaintive
- B. philosophical

- C. disparaging
  - D. apologetic
  - E. enthusiastic
- Correct Answer : C

7. The author's paraphrase of a statement by Samuel Johnson serves which of the following functions in the passage?

- A. it furnishes a specific example
- B. it articulates a general conclusion
- C. it introduces a new topic
- D. it provides a contrasting perspective
- E. it clarifies an ambiguous assertion

Correct Answer : B

8. The author of the passage is primarily concerned with

- A. reconciling opposing viewpoints
- B. encouraging innovative approaches
- C. defending an accepted explanation
- D. advocating an alternative interpretation
- E. analyzing an unresolved question

Correct Answer : D

### Answer Sheet

Treatment Letter:    A        B        C        D

First Passage Read :    Fossil    or    Literature

Material Used :        Hard-Copy    or    iPad

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

Second Passage Read : Fossil    or    Literature

Material Used :    Hard-Copy    or    iPad

- 1.
- 2.

- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

### General Student Questionnaire

Gender :    Male        or        Female

Grade :    10            11            12

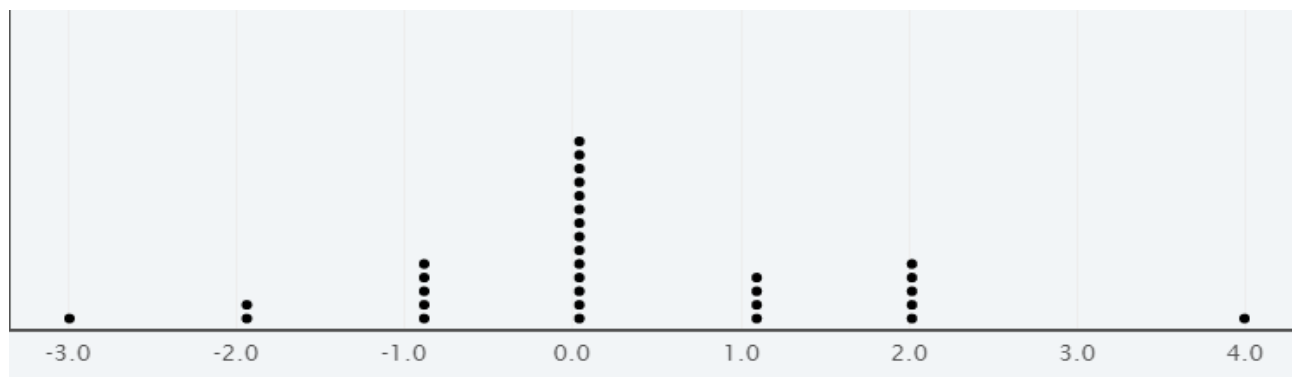
English Class Level :    Standard        Honors        AP

Native Language :    English        Chinese        Korean        Spanish        Other

\*Please do not discuss the content of the passages or the questions on the quizzes to any other students at our school until we have concluded our experiment. Thanks\*

## V. Description of Data

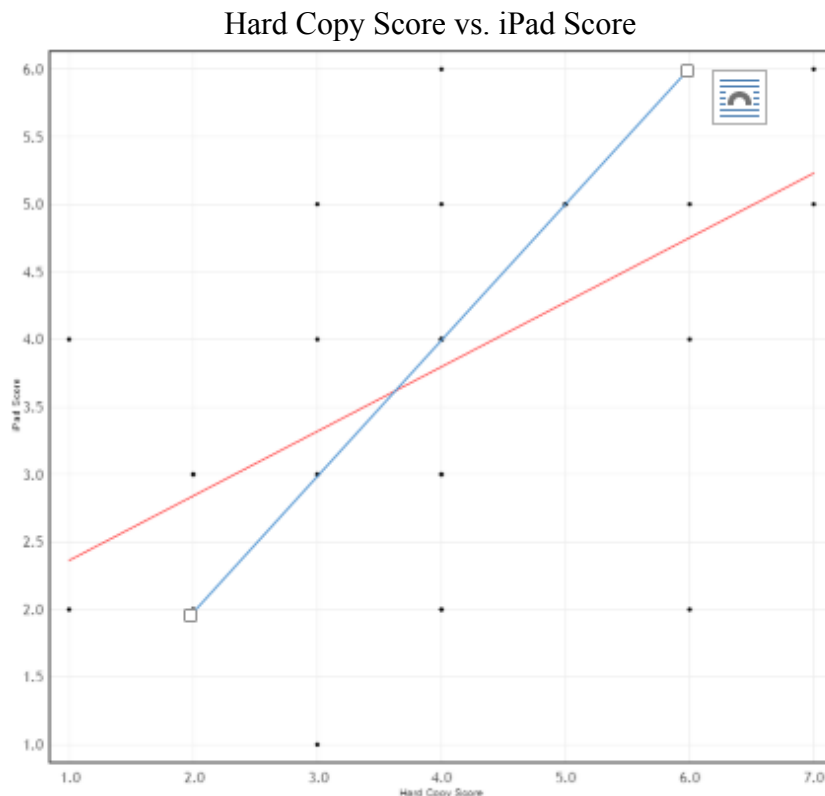
Appendix A contains a list of each subject's test scores.



Difference in Scores (Hard Copy - iPad)

Statistic	Value
Sample Size	32
Mean	0.188
Standard Deviation	1.401
Minimum	-3
Q1	-0.500
Median	0.000
Q3	1.000
Maximum	4

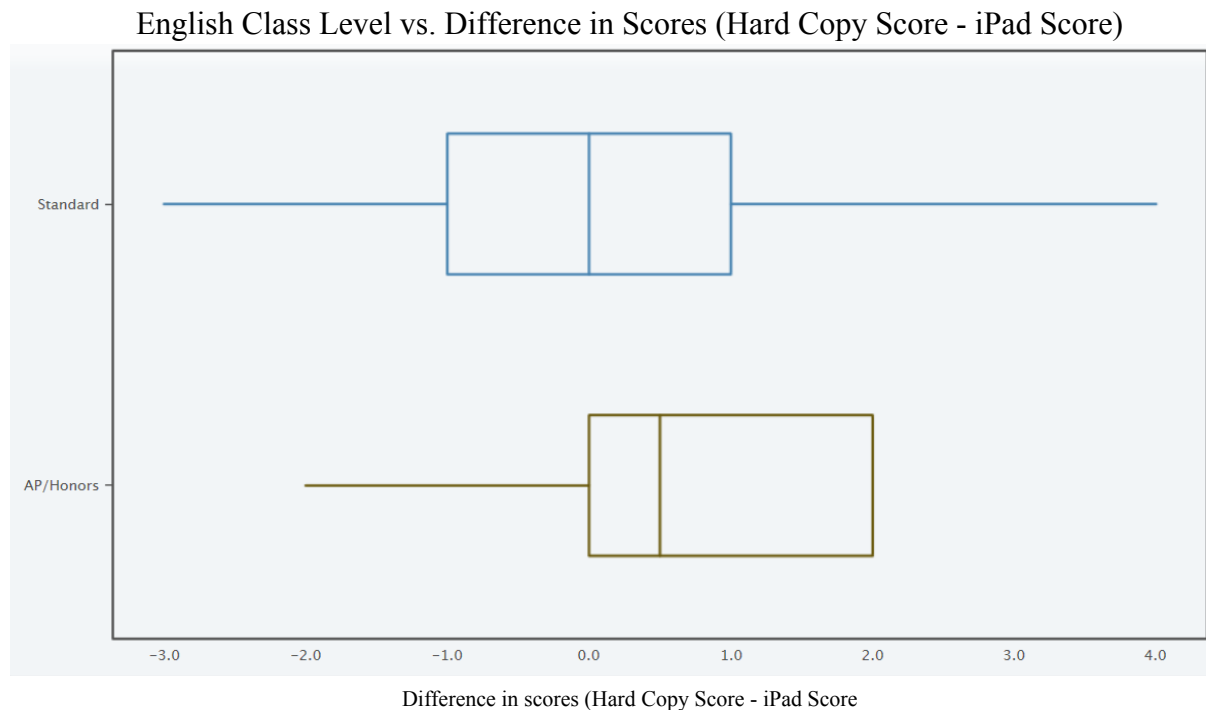
The dot plot of difference in scores (hard copy score - iPad score) has an approximately symmetric shape. The median of the graph is 0 points, while the mean is 0.188 points. The dot plot has a standard deviation of 1.041 points and a range of 7 points. Also, the interquartile range of the graph is 1.5 points. There are no apparent outliers in the dotplot, so we can assume that all of our data is reliable.



Statistic	Hard Copy Score	iPad Score
Mean	3.969	3.781
Standard Deviation	1.576	1.362
Sample Size		32
Correlation		0.553
Slope		0.478
Y Intercept		1.885
R Squared		0.306

From this graph, we can see that there is a moderately strong, positive, linear relationship between the hard copy scores and the iPad scores of the students who participated in our experiment. The slope shows that with every one point increase in the hard copy score, the predicted increase in the iPad score is 0.478 points. The y intercept shows that if the hard copy score was zero, then the predicted value of the iPad score would be 1.855 points. The r squared value shows that 30.6% of the variation in iPad score is accounted for by the least squares regression line.

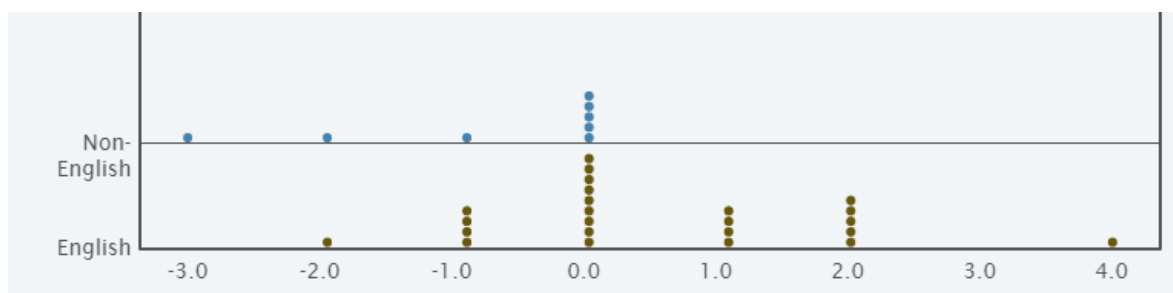
Our graph shows that the lower achieving students did better on the iPad passage questions than on the hard copy passage questions because the graph has a positive y-intercept. Higher achieving students seem to have higher hard copy scores than iPad scores because the slope is below 1, and even below .5. This does not directly prove our hypothesis because it shows lower achieving students as doing better on the iPad.



Statistics	AP/Honors	Standard	Overall
Sample Size	6	26	32
Mean	0.500	0.155	0.188
Standard Deviation	1.517	1.395	1.401
Minimum	-2	-3	-3
Q1	0.00	-1.00	-0.50
Median	0.50	0.00	0.00
Q3	2.00	1.00	1.00
Maximum	2	4	4

The boxplot for the differences of scores for students who are in the standard English classes has an approximately symmetric shape. The boxplot for the differences of scores for students who are in the AP/honors English classes has a shape that could be considered as skewed right but the sample size is extremely small. The median of score differences for the students who are in AP/honors English classes is higher at 0.50 points than the students who are in the standard English classes, which is at 0.00. The range of score differences for the students who are in the standard English classes is much higher at 7 points than the students who are in the AP/honors English classes, which have a range of 4 points. Also, the mean of score differences for students who are in the AP/honors classes is 0.500 points, while the standard deviation is 1.517 points. The mean of score differences for students who are in the standard English classes is 0.155 points, while the standard deviation is 1.395 points. There appears to be no outliers in either of the box plots.

Native Language vs. Difference in Scores (Hard Copy Score - iPad Score)



Difference in scores (Hard Copy Score - iPad Score)

Statistic	English	Non-English	Overall
Sample Size	24	8	32
Mean	0.500	-0.750	0.188
Standard Deviation	1.351	1.165	1.401
Minimum	-2	-3	-3
Q1	0.00	-1.50	-0.50
Median	0.00	0.00	0.00
Q3	1.50	0.00	1.00
Maximum	4	0	4

The dot plot for difference in scores for students whose native language is English has a shape that is approximately symmetric. The dot plot for difference in scores for students whose native language is not English has a shape that is quite skewed to the left. The median of score differences for students whose native language is English and not English is 0.00 points. The mean of score differences for students whose native language is English is 0.500 points, while the mean of score difference for students whose native language is not English is -0.750 points. The range of score differences for students whose native language is English is 6 points while the standard deviation is 1.351 points. The range of score differences for students whose native language is not English is 3 points while the standard deviation is 1.165 points. There are no apparent outliers in either of the dot plots that compare difference in scores and the student's native language that participated in our experiment.



## Grade Level vs. Difference in Scores (Hard Copy Score - iPad Score)

Difference in scores (Hard Copy Score - iPad Score)

Statistics	10th Grade	11th Grade	12th Grade	Overall
Sample Size	16	3	13	32
Mean	-0.188	1.333	0.385	0.188
Standard deviation	1.276	0.577	1.557	1.401
Minimum	-3	1	-2	-3
Q1	-1.00	1.00	0.00	-0.50
Median	0.00	1.00	0.00	0.00
Q3	0.00	1.50	1.00	1.00
Maximum	2	2	4	4

The dot plot for the difference in scores for students who are tenth and twelfth grade have a shape that is approximately symmetric. The dot plot for the difference in scores for students who are in eleventh grade does not have enough data points to conclude its shape. The median of score difference for students who are in tenth and twelfth grade is 0.00 points, while the median of score difference for students who are in eleventh grade is 1.00 points. The mean of score differences for students who are in tenth grade was -0.188 points, while the mean score differences for students who are in eleventh grade is 1.333 points. Also, The mean score differences for students who are in twelfth grade is 0.385 points. The range for differences in scores for students who are in tenth grade is 5 points, while the standard deviation is 1.276 points. The range for differences in scores for students who are in eleventh grade is 1 point, while the standard deviation is 0.577 points. The range for differences in scores for students who are in twelfth grade is 4 points, while the standard deviation is 1.557 points. There are no apparent outliers in the any of the dot plots that compare difference in scores and the student's grade level that participated in our experiment.

## VI. Analysis of Data

Since we used a matched pairs design for our experiment, we did a 1 sample t-test to see if there was a difference in number of questions answered correctly based on which material the student read the passage from. The hypotheses for this test was  $H_0 = \text{mean score difference} = 0$  and  $H_a = \text{mean score difference is greater than } 0$ , where mean score difference was the mean difference of correct answers on the reading comprehension quiz after reading from both the hard copy format and the iPad. We did a one sided test because we thought that there would be a

positive significant difference between the two scores on the quizzes meaning that the overall scores for the passage read on the hard copy version will be higher.

We also did a linear regression t-test to see if students with higher iPad score also had a higher paper score, or if the hard copy score on the comprehension quiz was the same as the iPad score on the comprehension quiz. The hypotheses for this test was  $H_0 = \text{slope} = 1$  and  $H_a = \text{slope} < 1$ , where slope is the slope of the least squares regression line for the scatterplot comparing hard copy scores and iPad scores. We used a slope of 1 in our hypotheses because that would be the slope of the least squares regression line if both of the scores on the comprehension quizzes were the same. We did a one sided test because we thought that the hard copy scores would be higher than the iPad scores making the slope positive but not more than one because that would mean that the two scores are equal. Also, as mentioned before, using a one sided t test makes it more likely for a test to find significance in a set of data.

We performed both of our tests at the 0.05 significance level. However, before doing our test, we made sure that the three conditions were met. The random condition was met because the passage that was read first and the material which the student read from first will be determined by one of the group members picking a slip of paper with the letter A, B, C, or D on it out of a container of letters that have been mixed thoroughly and that represent the four possible treatments. The independent condition will be met because we did a randomized experiment and we can conclude that the number of one student's answers that are correct on both tests does not affect the number of another student's answers that are correct on both tests. We can also assume that the students who took part in our experiment did not cheat on the two eight question quizzes or discuss their answers with other students at Christopher Dock before the experiment had concluded. We conducted our experiment on 32 Christopher Dock students who are at least in tenth grade and the t distribution is quite robust, which is large enough to assume an approximately normal sampling distribution.

### Matched Pairs T-Test

$$H_0 = \mu_D = 0$$

$$H_a = \mu_D > 0$$

$$t = \frac{\bar{x}_d - \mu}{\frac{s_d}{\sqrt{n}}} \quad t = \frac{.1875 - 0}{\frac{1.4013}{\sqrt{32}}} = 0.756911562$$

$$p\text{-value} = 0.2274126433$$

$$0.05 < 0.2274126433$$

Fail to Reject  $H_0$

## Linear Regression T-Test

$$H_0 = \beta = 1$$

$$H_a = \beta < 1$$

$$t = \frac{b - 1}{SE_b}$$

$$t = \frac{.4779 - 1}{.1314}$$

$$= -3.973363775$$

$$df = 32 - 2 = 30$$

$$p\text{-value} = .0002$$

$$0.05 > 0.0002 \text{ so Reject } H_0$$

## VII. Conclusion

Based on our statistical analysis using tests and graphs, we do not have strong enough evidence to conclude that there is a statistically significant difference in reading comprehension when a student reads on the iPad versus when they read from a hard copy format. Our matched pairs t-test ended up with a p-value of .227 which is larger than .05, so we failed to reject the null hypothesis, which states that the population mean difference between the hard copy score and the iPad score is zero. The sample mean difference between the hard copy score and the iPad score was positive, but the data was not statistically significant. The data was not very physically significant either because the mean difference was less than a point. The other statistical test that we performed was a linear regression t-test for slope. Our null hypothesis was that the slope of a regression line comparing hard copy score versus iPad score would be 1. The test came out with a p-value of .0002, which allowed us to reject the null hypothesis. This shows that it would not be feasible to say that the hard copy score would always be the same as the iPad score. If a larger sample size was used, the data might have reached a different conclusion for both of the t-tests we conducted. Overall we can conclude that for our volunteers, there is no difference in understanding the depth of content when a passage is read on an iPad or when it is read in the hard copy format.

## VIII. Things We Would Do Differently

If we were able to repeat this process again, there are a few things that we would do differently. If we conducted our experiment on more subjects, our sample size would have increased and this would have helped to make our results more conclusive. Both tests performed would then have more degrees of freedom, which would make the t-distribution closer to normal. The passages that were used in this experiment could be considered as quite difficult. If this experiment were to be repeated, easier passages might have been beneficial to our data because overall, the scores would have been higher. Easier passages would have been less frustrating to the subjects and it is possible that some students might not have tried their best in our experiment because they could have been discouraged by the difficulty of the passages. Less difficult passages would also enable us to shorten the time required for us to conduct the experiment, which would have made the data collection process easier. More subjects would probably

volunteer if they did not have to give up as much of their time and energy. If we had the ability to separate our subjects into different areas, making it so that they could not cheat or talk to each other, this would have been beneficial to our data and experiment as a whole. This would have ensured that no one was getting a different score than they should have gotten.

### IX. Areas for Further Study

To farther our studies, some different areas that we could look into would be a more diverse range of ages, different technologies, or to focus more on a certain area like language or english class level for instance. If we were to farther our studies on subjects of different ages, we would choose people of different ages that aren't in their high school years. We would probably choose younger kids, maybe six to eleven year olds, that know more about technology, and some older adults, maybe fifty to sixty year olds, that aren't as technology inclined. This would give us more diverse data that could possible cause us to have a different conclusion. Another aspect that we could look at would be technology. As a group we chose to use our iPads because everyone at our school has them. However, to look into the technology variable even more, we could use laptops, computers, or smartphones to diversify the technology being used and see if it has a different effect on our data. The last thing that we thought of to further our studies is to focus on a specific topic such as gender, english class level, or native language. We had made some graphs earlier in the report to see if there was a significant lead on one of these categories, but we didn't have enough data for any of the specific categories to prove something. However, it we looked closer at one of these groups, we may be able to find that certain people in these groups do better with technology, while others do not.

### X. Appendix

Test Subject Number	Treatment Group Letter	First Passage Read	First Material Used	First Score	Second Passage Read	Second Material Used	Second Score	Gender	Grade	English Class Level	Native Language
1	B	Fossil	Hard copy	4	Literature	iPad	3	Female	12	Standard	English
2	D	Literature	Hard copy	1	Fossil	iPad	2	Male	10	Standard	Chinese
3	C	Literature	iPad	3	Fossil	Hard copy	3	Male	10	Standard	English
4	A	Fossil	iPad	6	Literature	Hard copy	6	Female	10	Standard	Chinese
5	A	Fossil	iPad	5	Literature	Hard copy	6	Female	10	Standard	English
6	A	Fossil	iPad	2	Literature	Hard copy	2	Male	10	Standard	English
7	B	Fossil	Hard copy	4	Literature	iPad	2	Female	10	Standard	English
8	B	Fossil	Hard copy	4	Literature	iPad	4	Female	10	Standard	English

9	B	Fossil	Hard copy	4	Literature	iPad	2	Male	10	Standard	English
10	B	Fossil	Hard copy	3	Literature	iPad	5	Male	10	Standard	English
11	D	Literature	Hard copy	5	Fossil	iPad	5	Male	10	Standard	Other
12	D	Literature	Hard copy	3	Fossil	iPad	4	Male	10	Standard	English
13	D	Literature	Hard copy	5	Fossil	iPad	5	Female	10	Standard	English
14	D	Literature	Hard copy	1	Fossil	iPad	4	Male	10	Standard	Chinese
15	D	Literature	Hard copy	4	Fossil	iPad	4	Female	10	Standard	English
16	C	Literature	iPad	5	Fossil	Hard copy	4	Male	10	Standard	English
17	A	Fossil	iPad	5	Literature	Hard copy	5	Female	10	Standard	English
18	C	Literature	Ipad	3	Fossil	Hard copy	4	Male	11	Standard	English
19	D	Literature	Hard Copy	2	Fossil	Ipad	3	Male	12	Standard	English
20	D	Literature	Hard Copy	4	Fossil	Ipad	4	Female	12	AP	English
21	A	Fossil	iPad	6	Literature	Hard copy	7	Female	11	Honors	English
22	A	Fossil	iPad	4	Literature	Hard copy	6	Female	11	Honors	English
23	A	Fossil	iPad	5	Literature	Hard copy	7	Male	12	AP	English
24	B	Fossil	Hard copy	2	Literature	iPad	2	Female	12	Standard	English
25	C	Literature	iPad	1	Fossil	Hard copy	3	Female	12	Standard	English
26	C	Literature	iPad	5	Fossil	Hard copy	5	Female	12	Standard	English
27	B	Fossil	Hard copy	2	Literature	iPad	3	Female	12	Standard	English
28	A	Fossil	iPad	4	Literature	Hard copy	4	Female	12	AP	Chinese
29	C	Literature	iPad	6	Fossil	Hard copy	4	Female	12	AP	Korean
30	C	Literature	iPad	2	Fossil	Hard copy	6	Male	12	Standard	English

31	B	Fossil	Hard copy	4	Literature	iPad	4	Male	12	Standard	Chinese
32	C	Literature	iPad	3	Fossil	Hard copy	3	Male	12	Standard	Spanish

## XI. Works Cited

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