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Abstract

In recent years, students and educators alike have utilized new technologies such as tablet computers as a means of enhancing the learning process. While prior research suggests that these implementations within the classroom provide a new and beneficial method of relaying and learning information, scientists have begun to explore the possible side effects that these technologies have on the learning process. Although much of the current literature suggests that learning from an electronic screen does not affect efficacy compared to learning from printed text (Bayliss et al., 2012; Dundar & Akcayir, 2012), researchers continue to explore the possible consequences that using said technologies may have in academia. The current study aims to address how tablet computers affect the process of learning differently across levels of education. It is proposed that older generations, such as college students, who did not grow up with tablets in the classroom may suffer from the effects of proactive interference when compared to younger students who have been exposed to technologies much more profoundly in their education (e.g. elementary students). If this is so, the current study also proposes a possible intervention that would help students at any educational level overcome this interference in order to integrate tablets into their studies effectively.

Introduction

As the technological world continues to advance with rapid speed, educators look to integrate technology within the classroom with the hopes of augmenting the efficiency and efficacy of student learning. Over the past decade, many new technologies such as computers, laptops, high-speed Wi-Fi, cloud learning environments, and tablet computers have made there way into the classroom, becoming integral parts of the learning process. For example, in 1995 public schools across the U.S. had 5.6 million computers that were used for educational purposes and only a meager 8% were equipped with Internet access. By 2008, the number of computers within the classroom had augmented three-fold to 15.4 million and a staggering 98% of which had Internet access. In 2009, approximately 40% of teachers reported using new technologies such as computers regularly and an additional 29% of them used them periodically (National Center for Educational Statistics, 2010).

The use of technology in education has impacted the way that educators present information, the way students learn that information, and the overall availability of academic material. This implementation of technology is seen at various educational levels as it has provided new and interactive platforms of learning that can be adapted to suit the educational needs of students at any age (Marés, 2012) and promotes collaborative learning (Resta & Laferrié, 2007). In regards to the college setting, it is clear that technology has become heavily integrated; both professors and students utilize a myriad of different technological platforms to enhance the learning process. Studies indicate that more than 90% of college students own a laptop and use it both in and out of the classroom, a significantly higher proportion than what had been reported just years prior (Wook et al., 2013). Although technology integration within the college level has recently increased substantially, its implementation in the elementary level is even more profound as government policies have required the inclusion of such technologies to reduce the socioeconomic disparities within the classroom and to engage students in a greater capacity (Marés, 2012).

Although computer and laptop usage has increased at all levels of academia, one new form of technology that has rapidly made its way into the classroom is the tablet computer. Tablets are viewed as a revolutionary platform for learning and communicating in that they provide a portable and interactive method of consuming content and engaging with peers (Enrique, 2010; Simon et al. 2004). They also provide educators with a new method of teaching that integrates traditional presentation elements with a more dynamic and engaging presentation method (Rogers & Cox, 2008). A study exploring the perceptions of teachers in regards to tablet computers found a wide diversity of opinions, though many maintained positive outlooks on tablet usage in the classroom (Ifenthaler & Schweinbenz, 2013). A recent study that aimed to gauge the perceptions and attitudes held by students towards tablets indicates that students not only maintain positive attitudes towards the implementation of tablets in the classroom, but also perceive tablets as a more interactive, engaging, and effective educational tool compared to standard learning platforms (Bonds-Raacke & Raacke, 2008).

Some researchers argue that these perceptions are only the result of tablets being novelties in the classroom, while others purport that tablets actually do provide a more engaging method of learning, especially in subjects such as math and writing (Osman, 2011). These attitudes towards tablet use in the classroom are further exemplified by the rising rate of tablet ownership in college students, which nearly doubled from 2012 to 2013. A survey conducted at the University of Central Florida demonstrated that the population of students who own tablets and laptops rose to 30% from 2013 to 2014 (Chen & Denoyelles, 2013), suggesting that students view new technologies as advantageous to the learning process. Furthermore, 82% of student tablet owners proclaim that they integrate tablets into their academic lives and use them to further their learning (Chen & Denoyelles, 2013). At the elementary level, tablet usage is even more pronounced as government policies have mandated their usage in the classroom as an integral platform for teaching and learning (Osman, 2011). Elementary schools around the world have integrated tablet computers into the core of student curriculum with the hopes of enhancing the process of learning in the earlier stages of development (Marés, 2012). For example, according to a poll conducted on behalf of industry giant Pearson Education, in 2014 approximately 66% of elementary school students report using tablets regularly and 71% claim that it would be favorable to use them more often in their studies (Poll, 2014) Although many studies indicate that most young students exhibit positive attitudes towards tablet usage in the classroom, some populations that have had technologies heavily integrated into academic curriculum have reported that reading from tablets is more tiring than reading from printed text, which eludes to a possible consequence of tablet use in the classroom (Jeong, 2010).

As the integration of tablet usage in an academic capacity has grown exponentially, the possible effects that this platform has on actual learning have come in to question. One study conducted as a result of this ambiguity focused on the effects that tablet computers have on the learning process in elementary school students when compared with more traditional printed text (Dundar & Akcayir, 2011). The researchers had two groups of student participants, a tablet group and a paper group. All of the participants read standardized passages and were subsequently tested for reading comprehension and reading speed. The results of this experiment indicated that there was no significant difference in either reading speed or reading comprehension in elementary school students when they learned from tablets when compared with printed text, suggesting that tablets are not negatively interfering with the learning process (Dundar & Akcayir, 2011). While these results demonstrate that tablets may not have a detrimental effect on learning in elementary school students, the researchers reported that further investigations needed to be conducted in order to solidify this conclusion.

A study by Bayliss et al. (2012) addressed this topic in the college student population and found similar result. The researchers in this study aimed to see if there were any discrepancies in learning between tablets and printed text in college students, as well as the platform’s perceived usability in the classroom setting. The results indicated that there was no effect of text presentation on reading comprehension amongst this population and that college students perceive tablets as being more user friendly compared to written text, coinciding with prior literature regarding the attitudes of tablet usage in the educational sphere (Bayliss et al., 2012). Another similar study conducted by Margolin et al. (2013) examined the effect that the learning platform had on a college population more in depth by addressing both narrative, text that tells a story, and expository, text that provides information, material. In this experiment, undergraduate students were broken into three different test platform groups: a printed text group, computer group, and tablet PC group. The researchers administered a variety of standardized reading passages including both narrative and expository texts that the subjects were subsequently tested on for reading comprehension. The results of the experiment demonstrated similar results to the Dundar & Akcayir (2011) study in that there was no significant difference in reading comprehension across testing platforms (Margolin et al., 2013). These results further demonstrate that tablet computers do not have a detrimental effect on the learning process in any level of education. The researchers in this study did note that tablet learning might be different across different age groups as younger populations of students may have greater familiarity with integrating new technologies in the classroom (Margolin et al., 2013).

The effects of proactive interference within the procedural memory of reading can possibly explain the issue addressed in the Margolin et al. study regarding the potential differences in tablet learning between varying educational levels. Proactive interference refers to the difficulty or inability to learn new information as a result of previously learned material at the cognitive level (Lustig et al., 2001). In procedural memory (i.e. memory for performing particular actions or procedures), proactive interference can hinder the acquisition of new skills if preexisting memories of similar procedures are present. For example, an individual who has performed ballet for the past decade may have difficulty picking up hip-hop choreography because of their preexisting knowledge of ballet. Applying this interference to learning information off of new technologies, it would make sense that older populations would have difficulty learning from new platforms because they are already used to learning from more traditional platforms (e.g.

printed text). If this is the case, there may be a learning deficit in college students attempting to learn from tablets who grew up learning from textbooks compared to elementary school students who have grown up with the integration of newer technologies in an educational setting.

The current study aims to address the issue of proactive interference in tablet learning across educational levels. By comparing the college population with an elementary student population, a learning difference could suggest that tablets may be hindering the learning process of the older student population. In accordance with the theory of proactive interference, the older population that relied on printed text as the primary form of learning should exhibit learning deficits when compared to the younger population. Although previous studies have addressed both of these populations and have noted no differences in learning and reading comprehension in regards to learning platform, none have compared these two populations in attempt to highlight any learning discrepancies. If reading discrepancies are found between the two populations, this could have major implications regarding the impact of technologies in the college setting, demonstrating that using tablets for academic purposes could be detrimental to effective learning in older populations. Because it is hypothesized that there should only be a reading deficit found in the older population, the current study will also address a possible intervention that would allow college students to overcome the effects of proactive interference associated with learning from newer technologies.

EXPERIMENT 1

Method

Participants

A total of 40 undergraduates from the Claremont Colleges (20 male and 20 female) and 40 4^{th} grade students from Chaparral Elementary School (20 male and 20 female) will be recruited to participate in this experiment. Of the undergraduate students, an effort will be made to diversify the sample with equal representation from each of the five colleges. A link to participate in the experiment will be placed on to the Claremont Colleges' social media pages in order to recruit participants. Once ample respondents sign-up, an equal amount of undergraduates (n = 40) from each of the five colleges will be randomly selected and sent a recruitment form detailing some of the experiment and incentivizing them with a chance to win a $30 gift card. After being informed of the experiment, the fourth grade teachers at Chaparral Elementary School will be asked to randomly select a total of 40 students to participate in the experiment after gaining parental consent. The classes from Chaparral Elementary School that choose to participate will each receive a class pizza party as an incentive. An additional parental consent form will be sent to the parents of each of the elementary school students that are selected to participate. The elementary school students recruited must have had tablet computers heavily integrated into their educational instruction, and it is assumed that the college students received their primary education via printed text.

Materials

In order to gauge the reading comprehension of two populations that are at completely different stages of cognitive development, standardized reading comprehension prompts and tests designed for each of the two educational levels will be used. For the elementary school group, a short passage called *Maria Martinez – Potter* by Sue Massey will be used as the testing prompt. This passage, along with four multiple-choice questions, was used in the California Standardized Test in 2008 as a passage to test the reading comprehension level in fourth grade students (see Appendix A & B). To test the reading comprehension in undergraduate students, a standardized reading comprehension passage from a previous SAT test, accompanied by seven multiple-choice questions, will be used (see Appendix C & D). The prompts will be administered on either an iPad 4 screen or printed out on an 8 x 11 sheet of copy paper. The font (Times New Roman) and font size (12) will be consistently displayed throughout all of the testing platforms. In order to ensure font size consistency in the tablet group, participants will be asked not to "zoom" in or out on the screen. The distractor task will consist of a simple maze designed to take approximately five minutes to complete. The multiple-choice questions will be printed out on an 8" x 11" sheet of paper for all of the testing conditions.

Procedure

Based on their education levels, the participants will be randomly assigned to one of four conditions: elementary & paper test (n = 20), elementary & tablet test (n = 20), college & paper test (n = 20), or college & tablet test (n = 20). All of the experiments will be performed in The Human Learning and Memory Lab at Claremont McKenna College, which will provide a quiet and isolated testing environment. Each of the elementary school students will be required to submit a parental consent form prior to participating.

For the college participants, the experiment will be broken into two phases, a study phase and a test phase, with a simple distractor test in between. The duration of the experiment should be approximately 20 minutes for each of the participants. During the study phase, the college participants will be given the same literary passage from the SAT reading comprehension test and will be allotted eight minutes to read the material. The participants in the paper group will be given a printed, paper version of the passage, while those in the tablet group will be instructed to read the passage from an iPad. Upon completion of the study phase, the prompts will be removed and replaced with the distractor task. After five minutes elapse, the distractor task will end and the test phase will begin. Each participant will be given the same 7-question test to gauge their reading comprehension and will be allotted seven minutes to complete the task.

In the elementary school group, the students will undergo a similar process as their collegiate level counterparts. The only difference between the two groups will be the actual prompt material and test questions as they have been adjusted for educational level. In the study phase, each participant will be given an excerpt from the California

Standardized Test that was designed to measure the reading comprehension in fourth grade students. The passage will be displayed either on an iPad or printed on paper depending on which group the participants fall under. After a brief distractor test, the participants will be allotted seven minutes to complete a 4-question test to gauge their reading comprehension of the test material.

Projected Results

To examine the effects of testing platform and education level on reading comprehension, a 2 (test platform: paper, tablet) × 2 (education level: elementary, college) between subjects analysis of variance will be conducted. Due to the fact that the college test consist of seven questions while the elementary test only has four, each of the participants' test results will be calculated into percentages so that they could be translated into a score varying between 1-10 (e.g. 4/7 => 57.14% => **5.7**/10). Table 1 depicts the comparison of projected means and standard deviations of the reading comprehension scores for each of the four testing conditions. Each of the tests that aim to measure the reading comprehension of the participants should be designed to demonstrate high internal validity, which can be established if the tests' have a Chronbach's $\alpha > .80$.

In accordance with our hypothesis, there should be a significant interaction found between testing platform and education level. When the test material is presented on a tablet, the college students (M = 6.20, SD = 0.89) are projected to demonstrate significantly lower reading comprehension scores compared to the elementary school students (M = 7.05, SD = 0.39), $F(1, 76) = 15.30$, $p < .001$. This interaction is graphically depicted in *Figure* 1. The projected results demonstrate that there should be no main effect of testing platform and that on average, participants who take the paper version (M = 6.60, SD = 0.63) will not have significantly different reading comprehension scores compared to those who take the tablet version (M = 6.62, SD = 0.81), $F(1, 76) < 1$, *n.s.* Similarly, there should not be a main effect of education on reading comprehension scores between the elementary school students (M = 6.75, SD = 0.54) and the college students (M = 6.48, SD = 0.54), $F(1, 76) = 3.50$, $p > .05$. These results would comply with our hypothesis in that college students seem to exhibit a deficit in learning from tablets compared to elementary students who have been primarily educated by tablets and technology.

Discussion

As new technologies have been integrated into the realm of education, scientists have attempted to uncover the effects that these technologies have on learning. The current study aims to address the effects that tablets have on learning across educational levels. Prior studies that have looked at the effects of tablets and similar technologies on learning have studied participants at both elementary and collegiate levels (Bayliss et al., 2012; Dundar & Akcayir, 2012). The results of these prior studies demonstrate that aspects of learning such as reading comprehension are unaffected by the testing platform, although no prior studies have examined this effect across different educational levels (Margolin et al., 2013). The background literature suggests that learning from tablets has no detrimental effects at any level, and therefore can be implemented into the academic sphere without any learning consequences (Bayliss et al., 2012; Dundar & Akcayir, 2012; Margolin et al., 2013). The current study aims to refute these claims in an effort to illuminate a learning discrepancy between an older population (college students) that has been engaged in learning from printed text for the majority of its education and a younger educational level (elementary students) that has had such technologies heavily integrated throughout the entirety of the educational process. The projected results of the current study indicate that there may be a learning discrepancy between educational levels in regards to learning from tablets, and that this difference is most likely the result of proactive interference occurring in the older population.

The goal of the current study is to examine the effects of testing platform and educational level on reading comprehension in order to address any learning deficits that students might face in their academic lives as a result of technological implementations in the classroom. Consistent with prior literature, the projected results indicate that there should be no significant effect of testing platform on reading comprehension. This would suggest that when averaged across the levels of education, the effects that tablets may have on learning in an academic setting are probably minute. Additionally, our results predict that there is also no impact of education level on reading comprehension within the experiment, which would implicate that our two different reading comprehension tests that were education level specific are comparable to each other in regards to difficulty. Consistent with our original hypothesis that proactive interference may hinder the learning process in college students when learning from tablets, the projected results of this experiment demonstrate a significant interaction between the educational level of the participants and the testing platform. Looking more specifically at the tablet test condition, the college level participants should score significantly lower on a reading comprehension test than the elementary group. This result would imply that when compared to a population of students (e.g. younger grade levels) that has always used technologies, such as tablets, in an educational setting, older generations that have been educated primarily with printed text might be at a learning disadvantage when using tablets for academic purposes due to the consequences of proactive interference. While the projected results suggest that older generations could be at a learning disadvantage when using newer technologies, they show that actual technologies aren't negatively affecting the learning process and that it is simply the lack of familiarity with the technology that causes learning discrepancies. Furthermore, the prior findings that claim that new technologies provide a more engaging and effective mode of educating (Bonds-Raacke & Raacke, 2008; Wook et al., 2014) are still pertinent to younger and future generations of scholars.

Although the projected results of the current study would maintain our initial hypothesis, there were several limitations that could potentially skew our findings. The most profound limitation of our study is that in comparing the reading comprehension scores of two different educational levels, we cannot give them the same test. While the difficulty of both tests is adjusted for grade level, factors regarding the semantic material presented in the passages as well as the difference in test length may confound our results. Additionally, our selected samples for both populations may not have been representative of the target populations. In the college population, recruiting students from the Claremont colleges may not lead to an accurate representation of the entire college population as the environment is highly selective and competitive. For the elementary level, we will only recruit a sample from one grade level at one elementary school, which also is most likely not representative of elementary school students nationwide. The learning difference predicted between the two educational levels may also be affected by something other than proactive interference. Some research suggests that younger children are more motivated to learn when using novel technologies in the classroom, which subsequently enhances the learning process (Couse & Chen, 2010). If this is the case, younger educational levels may benefit more from using tablets and technology because they are incentivized by the novelty of using technology as a means of studying; this effect of technology on motivation and subsequent learning has not been noted in older students.

As educators continue to implement new technologies in the classroom, it is imperative that scientists explore both the positive and negative effects that these technologies have on learning. The current study could illuminate one potential drawback of using technologies, such as tablets, as a means of encoding information, especially in education levels where said technologies are more novel. While the learning deficit targeted in the current study by older generations could be significant, further research should see if there are ways to overcome the negative effects of proactive interference that coincide with learning from technologies, especially since their use in an academic capacity is both inevitable and growing substantially across all education levels. The next experiment will examine this issue further by implementing an intervention that aims to directly negate the possible consequences of proactive interference associated with tablet use in college students.

EXPERIMENT 2

Introduction

In a college setting, the implementation of technologies in the learning process is inevitable as educators strive to augment the efficacy of teaching methods. The advent of tablets allows for a learning platform that has been shown to enhance critical thinking and creativity while providing a more engaging and interactive method of study for the student (Mang & Wardley, 2012). Additionally, college professors today are beginning to adopt the attitude that implementing tablets within their curriculum enhances dynamics during lectures, better engages students, and eases the process of teaching (Rogers & Cox, 2008). Current research indicates that the popularity of tablet use in college students has increased dramatically in the past few years with 89% of tablet owners using the technology for academic purposes (Chen & Denoyelles, 2013). This growing statistic has been the focus of a recent study that explored the benefits of tablet computer use in undergraduate education, which claims that tablets lead to better learning by facilitating students engagement, cooperation, and active learning (Cromack, 2008). While experiment 1 examined the possible effects that tablets have on the learning process across education levels, the current experiment aims to focus on the possible detriments that utilizing such technologies has in post-secondary education (e.g. college students).

As the use of technologies, such as tablets, in the post-secondary education has increased in the past decade, scientists have aimed to examine the possible effects that using such technologies might have on the learning process. Prior research examining the impact of tablets on reading comprehension in college students suggest that there is no difference in learning when subjects read material from tablets or printed text (Bayliss et al., 2012). The results from experiment 1 of the present study refute prior findings and demonstrate that there may be a learning deficit in college students when they choose to study information from tablets. This hindrance to the learning process is most likely due to the effects of proactive interference; the college students today did not grow up with technologies such as tablets in the classroom and therefore hinder the learning process when utilizing such technologies for encoding information. This deficit was also seen in a prior study that examined the effects of familiarity and testing platform on reading comprehension in college students (Chen et al., 2014). In this study, the researchers found that students who scored higher on a tablet familiarity questionnaire performed significantly higher on a reading comprehension test that was displayed on a tablet compared to those who scored lower (Chen et al., 2014).

Due to the fact that attempting to stop the influx of technology use in the classroom is out of the question, is there another way to reduce the negative consequences of proactive interference in the college domain? The current study aims to address this issue by proposing an intervention in college students that will allow them to overcome the effects of proactive interference when utilizing tablets for learning purposes. To negate the effects of proactive interference when college students use tablets in the learning process, we must first identify the cause of the interference. Due to the fact that college students today initially learned to encode information via printed text, it is safe to assume that the proactive interference is a result of an attempt to encode information from a completely different platform (e.g. tablet screens). The initial process of reading, encoding information from text, is associated with procedural memory (Mochizuki-Kawai, 2008). Prior studies that have aimed to negate the effects of proactive interference in procedural memory have attempted to reduce the retention of a previously learned skill so that the second skill would not be negatively affected (Carthos et al., 2006). In our predicament, it would be impossible to inhibit the procedural memory for reading information from printed text, so the only way to overcome the effects of proactive interference would be to dissociate the procedure of reading off of tablets from reading off of printed text. In order to achieve this, an intervention aiming to dissociate the two processes would have to make learning from tablets its own process; essentially familiarizing the participants with reading off of tablets to the point where it has become just as natural as reading from printed text. Research that has explored the possible detriments of tablet use suggests that users often are hindered as a result of being unfamiliar with the platforms interface (Hernon et al., 2007), which will also be addressed by our familiarity intervention.

If the proposed intervention were to be successful, one would expect that a sample of college students who completes the intervention to be able to overcome the effects of proactive interference when learning from tablets. By comparing the intervention sample with a sample of college students who have not been subjected to the intervention on a reading comprehension test, any discrepancies in reading comprehension should be indicative of the effectiveness of the intervention. In experiment 2, a group of college students will undergo a four week tablet familiarity intervention aimed to dissociate the process of learning off of a tablet from learning off of printed text. At the end of the intervention, the experimental group will be tested for reading comprehension in either a tablet or paper test and their scores will be compared with a control group. We hypothesize that the intervention will negate the effects of proactive interference, resulting in the experimental group outperforming the control group on a reading comprehension test when the test material is presented on a tablet. The results of experiment 2 should shed light on how college students can effectively overcome the consequences of learning from tablets found in experiment 1.

Method

Participants

The participants of this study will consist of 80 undergraduate students from the Claremont Colleges (40 male and 40 female). To recruit students, a link to participate in the experiment will be posted in each of the five colleges' social media pages detailing that each participant will be given $20 upon completing of the experiment. Upon receiving an ample number of student sign-ups, an equal number of respondents from each of the five colleges will be randomly selected to participate in the actual experiment.

Materials

A standardized SAT reading comprehension passage will be used as the testing prompt in all of the conditions (see Appendix E & F). The prompt will be administered on either an iPad 4 or printed out on an 8 × 11 sheet of copy paper. The page layout, font type (Times New Roman) and font size (12) will be consistent in all of the testing conditions. To ensure font size consistency, those that are shown the prompt on an iPad will be instructed not to zoom in or out on the screen. A standardized reading comprehension test designed for the prompt and comprised of seven multiple-choice questions will be administered to measure the participants' reading comprehension. The actual test will be printed and completed on an 8 × 11 sheet of paper for all conditions. The distractor task will consist of a simple maze designed to take approximately five minutes to complete. Additionally, an iPad 4 will be given to each of the students who are selected to participate in the tablet familiarity intervention (n = 40) for the duration of the intervention period.

Tablet Familiarity Questionnaire: In order to gauge the effectiveness of our intervention and provide a baseline level of tablet familiarity in college students, the Tablet Familiarity Questionnaire (TFQ) developed in a previous study (Zheng et al., 2014) will be used. The questionnaire, which was designed to measure participants' tablet familiarity, consists of 32 items across five factors: 1) ability of using tablet computers, 2) use of and experience with tablet computers, 3) availability to tablet computers, 4) use tablet computers for entertainment and 5) problem solving when encountering difficulties. The questionnaire is considered reliable with a Chronbach's alpha coefficient of 0.916 (see Appendix G).

Procedure

The participants will be randomly assigned to one of four conditions: intervention & paper test (n = 20), intervention & tablet test (n = 20), control & paper test (n = 20), or control & tablet test (n = 20). Once the participants have been randomly assigned to a group, all of the participants will be sent a link via e-mail to complete the Tablet Familiarity Questionnaire in order to gauge the baseline tablet familiarity for both the intervention groups and the control groups. After the intervention period, which will be detailed below, the intervention groups will re-take the Tablet Familiarity Questionnaire to gauge the validity and effectiveness of the intervention. Additionally, all of the subsequent experimental tests will be performed in The Human Learning and Memory Lab at Claremont McKenna College.

Tablet Familiarity Intervention: The participants who have been randomly assigned to an intervention group will undergo a four-week long intervention designed to naturalize the process of learning from tablets. The intervention will consist of a brief familiarizing phase and will be followed by an integration phase.

Familiarizing phase: Although a good proportion of the participants will probably have a decent amount of tablet familiarity, this phase will ensure that all of the participants in the intervention group will be able to use tablets effectively for the integration phase. At the beginning of this phase, all forty of the intervention participants will be given an iPad 4 to use for the duration of the intervention period. An Apple representative will be hired to instruct the participants for the duration of the familiarizing phase, which should take between 1-2 hours. Upon receiving their iPads, the participants will be instructed on the hardware mechanisms of the device (e.g. home and power buttons) and how to set-up the device for personal use. Once all of the participants have successfully set-up their tablets, the instructor will demonstrate how to use the application Adobe Reader for academic purposes. The participants will gain insight on how to efficiently utilize the app for reviewing lecture slides, taking notes, and reading course material. Once the instructor has finished demonstrating how to properly use the tablet and Adobe Reader, the participants will have a chance to ask any further questions about using the device for their class studies, marking the end of the familiarizing phase.

Integration Phase: After the participants in the intervention are instructed on how to properly use tablets, the researchers will mandate how the devices should be integrated into their daily academic lives. The participants will be instructed to take the tablets to every class that they attend and will be expected to download all of their course materials (if applicable) instead of printing them out. Additionally, they will be expected to utilize the tablets for taking class notes and annotating the required reading content of each course. In order to ensure that the participants are effectively dissociating the process of learning off of tablets from learning off of printed text, the participants will be instructed to use the tablets when studying information for all quizzes and exams taken during the intervention period. The participants will integrate tablets into their academic studies for a four week period to complete the intervention. Upon completing the intervention, all of the participants in this group will re-take the Tablet Familiarity Questionnaire to gauge the intervention's effectiveness.

Experimental Task: Once the intervention groups have completed the four-week Tablet Familiarity Intervention, all of the participants in the experiment will partake in the experimental task. The experimental task will be similar to that performed in Experiment 1, except there will only be one standardized prompt as all of the participants are in the same level of education. The experiment will be broken into two phases, a study phase and a test phase, with a brief distractor task in between. For the study phase, the participants will be allotted eight minutes to read the testing prompt and the material will either be presented on an iPad or on printed text depending on which condition they are assigned to. Once the study is has ended, the prompt will be removed and replaced with a brief distractor task that the participants will have five minutes to complete. Upon the completion of the distractor task, all of the participants will have seven minutes to complete a seven item multiple-choice test to gauge their reading comprehension of the passage.

Projected Results

In order to examine the effectiveness of our Tablet Familiarity Intervention, a between subjects independent samples t-test will be performed on the Tablet Familiarity Questionnaire scores of the control group and the post-intervention group. Assuming that our intervention is successful, it is projected that there will be a significant difference in tablet familiarity between the two groups with the post-intervention group (M = 7.5, SD = 0.5) scoring higher than the control group (M = 4.5, SD = 0.5), $t(1, 78) = 26.50$, $p < .001$.

Once the effectiveness of our intervention is established, we will examine the effects that our intervention and testing platform has on reading comprehension. To achieve this, a 2 (experimental group: intervention group, control group) × 2 (testing platform: paper, tablet) between subjects analysis of variance will be conducted. See Table 2 for the projected means and standard deviations of reading comprehension scores for each of the four experimental conditions. In accordance with our hypothesis, our projected results should demonstrate that there is a significant interaction between the experimental group and testing platform. When the participants are presented the testing material on a tablet, those that are in the intervention group (M = 5.05, SD = 0.39) should score significantly higher on the reading comprehension test than the participants in the control group (M = 4.28, SD = 0.80), $F(1, 76) = 14.69$, $p < .001$. *Figure 2* depicts this interaction and shows the comparison of projected reading comprehension scores for each of the experimental conditions. While an interaction between testing platform and experimental group is predicted, we do not project a significant main effect of testing platform and that on average, the participants who are administered the test on paper (M

= 4.60, SD = 0.63) will not perform significantly different from those that are given a tablet version (M = 4.66, SD = 0.74), $F(1, 76) < 1$. *n.s.* Additionally, we do not predict a significant main effect of experimental group on reading comprehension between the intervention group (M = 4.75, SD = 0.54) and the control group (M = 4.51, SD = 0.54), $F(1, 76) = 2.87$, $p > .05$. The projected results are in line with our hypothesis in that once participants dissociate the process of learning from a tablet with learning from printed text, they should outperform their peers on a reading comprehension test when the material is presented on a tablet because they no longer suffer from proactive interference.

Overall Discussion

Due to the increasing influx of technological usage in academia, the effects that using new technologies have on the learning process have become a critical target for scientists. The current study attempts to further the current research surrounding this topic by addressing how learning from tablet computers may affect populations from various educational levels differently. Prior research regarding this issue has failed to find any significant learning impairments associated with learning from tablets and suggests that they provide an enhanced learning experience in students of all ages (Bonds-Raacke & Raacke, 2008; Wook et al., 2014). The idea that using tablet computers for the learning process harbors no learning consequences in any level of education is challenged in our first experiment. Experiment 1 aims to illuminate a learning difference between students who have had technologies integrated in the classroom setting (e.g. elementary students) and those who have learned to encode information primarily from printed text (e.g. college students). We theorize that the older population of students will suffer from the effects of proactive interference when using tablets for learning, while the younger population of elementary school students should remain unaffected. Our projected results demonstrate that while there is no expected main effect of education level nor testing type, there should be a significant interaction between the two variables. If our hypothesis of proactive interference is correct, the college population should exhibit a learning deficit in reading comprehension when encoding information on tablets compared to the elementary school students.

Building off of the projected results from Experiment 1, Experiment 2 aims to address the learning deficit that college students may suffer from when utilizing tablet computers in their academic studies. This study proposes a Tablet Familiarity Intervention that is designed to dissociate the process of learning via reading printed text from that of reading off of a tablet screen. If the intervention is successful, college students who choose to use tablet computers for studying should be able to overcome the effects of proactive interference because the process of reading from printed text will no longer cognitively interfere with the process of reading off of tablets. The effectiveness of our proposed intervention can be tested systematically by the experimental task presented in Experiment 2. By comparing the reading comprehension scores from a control group of college students with the scores of an intervention group across testing platforms, we can determine both the effectiveness of our intervention and demonstrate a means of successfully overcoming proactive interference. In order to assess the effectiveness of our familiarity test, a Tablet Familiarity Questionnaire was taken by the participants in both the experimental groups and control groups. Comparing the familiarity scores of the two groups, the projected results indicate that the post-intervention groups score significantly higher in tablet familiarity than the control groups, which is indicative of the internal validity of the actual intervention. Although the projected results of our experiment show that there are no significant main effects of either the experimental group or testing platform, a significant interaction between the two factors is predicted. The projected interaction should demonstrate that when testing material is presented on tablets, participants from the intervention group should outscore those in the control group because they no longer suffer from proactive interference when learning from tablet screens.

On a broader scale, the results of this study implicate a possible consequence of implementing new technologies in an academic setting, especially when the population has not experienced the technology in an educational capacity. If the hypothesized interference is actually occurring in the learning process of students today, the projected results of Experiment 2 show that this negative effect on learning can be rectified by implementing interventions that are specifically designed to counteract the interference. The effectiveness of such interventions reassures us that the possible negative consequences of increased usage of new technologies in the classroom can be overcome.

Due to the fact that the projected results of this study would ideally coincide with our hypothesis, there is a very real possibility that the actual results could turn out much differently. In Experiment 1, we predict that there will be a learning difference between educational levels in our tablet condition based on the theory of proactive interference. If our results complied with prior studies (Bayliss et al., 2012; Dundar & Akcayir, 2012; Margolin et al., 2013) and were to demonstrate that there was no significant interaction between testing platform and education levels, it would implicate that there is no negative consequence when using novel technologies as a means to study information in at any education level. This result would actually be reassuring because it would demonstrate that the increase in tablet usage in the classroom is not hindering the learning process and may in fact be beneficial for students at any age. If there is in fact a negative effect on learning when using new technologies in older populations, Experiment 2 proposes a possible solution to overcoming this problem. If the results of Experiment 2 were to demonstrate that there is no difference in reading comprehension between college students who are familiarized with tablets and those who are not, it would indicate that either the intervention was not actually effective in counteracting proactive interference or that proactive interference is not responsible for a learning deficit in college students. If the latter were to be true, further studies would have to be conducted in order to determine which cognitive theory is responsible for the projected learning discrepancy between educational levels in regards to encoding information via new technologies.

The proposed study aims to address the possible effects that using new technologies, such as tablets, could have on the learning process. Although prior research has demonstrated that using such technologies does not hinder the process of encoding information (Bayliss et al., 2012; Dundar & Akcayir, 2012; Margolin et al., 2013), the projected results of this study show that there is still much that must be observed before that claim can be made. Because of the limited sample of the current study (i.e. fourth grade students and college students), future research should look more in depth at the effects of technology use in all levels of education. Additionally, the current study attributes the negative effects of learning from novel technologies to the theory of proactive interference. It is possible that proactive interference may have nothing to do with the possible learning deficits described in the current study and that other factors, such as the environmental factors of encoding, could be responsible. Regardless of the actual results of the proposed experiments, the current study conveys that there is still much that we don't know regarding the effects that using new technologies has on the efficacy of learning. As technologies continue to be integrated in the classroom, scientists and educators must continue researching the possible effects that such implementations may have on the learning process.

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Table 1

Comparison of Reading Comprehension Scores Between Conditions (Exp. 1)

	College Students			Elementary Students		
Test Type	*M*	*SD*	*n*	*M*	*SD*	*n*
Paper Test	6.75	0.72	20	6.45	0.51	20
Tablet Test	6.20	0.89	20	7.05	0.39	20

Table 2

Comparison of Reading Comprehension Scores Between Conditions (Exp. 2)

	Intervention Group			Control Group		
Test Type	*M*	*SD*	*n*	*M*	*SD*	*n*
Paper Test	4.45	0.51	20	4.75	0.72	20
Tablet Test	5.05	0.39	20	4.26	0.80	20

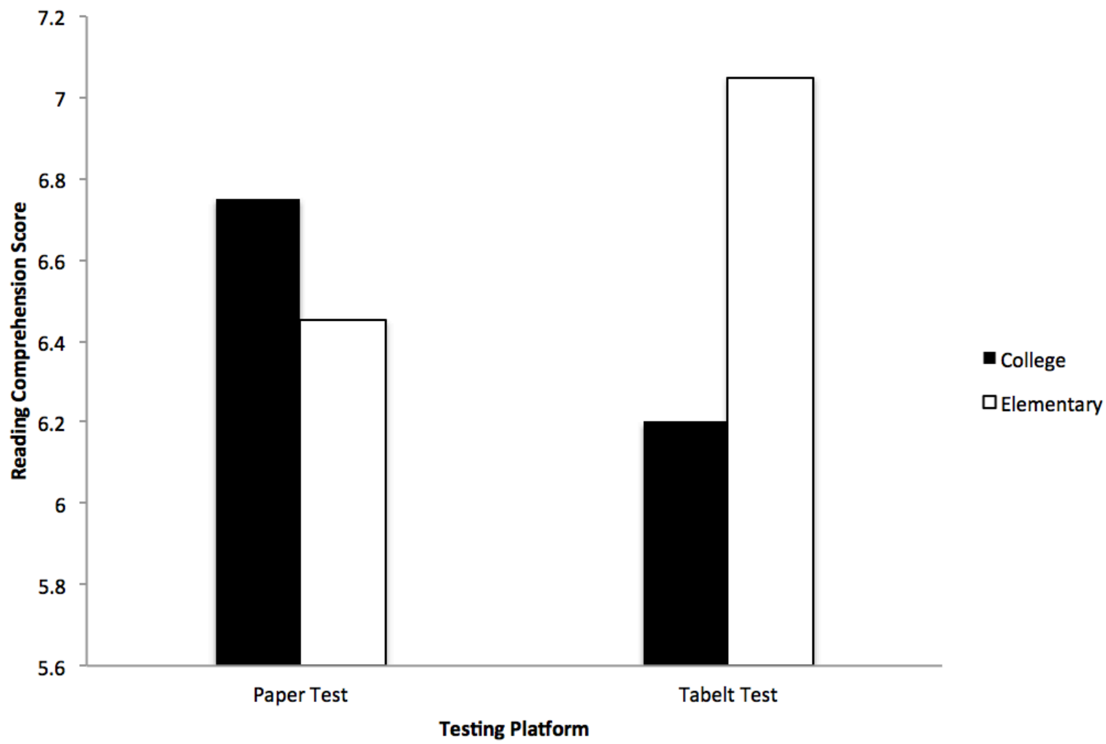

Figure 1. This figure depicts the projected results of a 2 (test platform) × 2 (education level) between subjects ANOVA from Experiment 1. These results indicate that there should be a significant interaction between testing platform and education level, $F(1, 76) = 15.30$, $p < .001$.

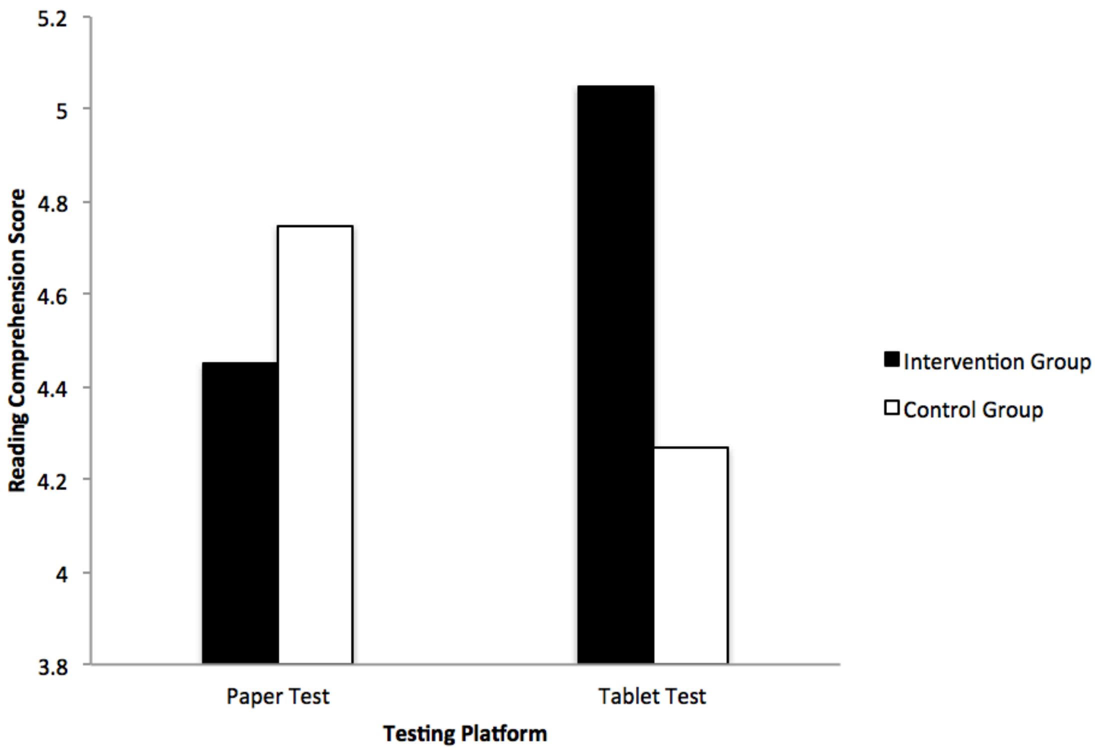

Figure 2. This figure depicts the projected results of a 2 (experimental group) × 2 (test platform) between subjects ANOVA. This figure demonstrates that there is a significant interaction predicted between experimental group and test type, $F(1, 76) = 14.69$, $p < .001$.

Appendix A

Elementary Level Testing Prompt (Experiment 1)

Maria Martinez – Potter

By Sue Massey

Maria Martinez is remembered today as the maker of beautiful pottery. Her pottery is in museums all over the world. The pots she made are black with shiny designs on them.

Maria Martinez was a Tewa Native American. She was born around 1881. Maria lived in San Ildefonso, New Mexico.

As a young woman, Maria was known for the fine pots she made. Maria and the other village women made pots for their families. They also sold pots to visitors. Compared to the pots made by the other women, young Maria's were lovely. But they were not outstanding. They were not the pots that would make the name Maria Martinez known around the world.

In 1908, special visitors came to Maria's village. The visitors were archaeologists. They were looking for remains of early Native-American life. The visitors had been digging near Maria's village. During the dig, they had found broken bits of pottery. The pots had belonged to a group of Native Americans who had lived there seven hundred years before. The visitors' finds influenced Maria's art. They also changed her life.

One of the archaeologists showed Maria the pieces of broken pots. They were thinner than the pots Maria was making. They had an odd, shiny black finish. He asked

Maria if she could make such a pot. He wanted it to be just like a seven-hundred-year-old pot. Maria said she would try.

Maria's husband, Julian, helped her. First they had to find a way to make the wall of the pot thinner. Maria knew that the clay she was using would not work. A thin pot made out of that clay would crack when it was fired. Maria mixed different amounts of clay, sand, and water. At last, she discovered a mix that would not crack.

Maria and Julian then had to find out how the shiny black finish had been made. They discovered that it took two steps.

First, Maria began by polishing the dried clay surface of the pot. She used a smooth stone as her polishing tool. It was slow work. Then, when the pot was polished, she placed it in a fire that was built in a certain way. The fire and ashes worked their magic on the pot. Its finish was now shiny and black.

Maria and Julian had discovered the secrets of the early pottery makers. The search for the secrets had excited Maria. She was eager to make more pots in the old way. And she did. For more than seventy years, Maria stayed in her village making pots.

Maria produced many pots in her lifetime. Under Maria's direction her son and grandson also learned how to make beautiful pots. They are keeping the old ways alive just as Maria had done before them.

Appendix B

Elementary Level Reading Comprehension Test (Experiment 1)

1. **"A thin pot made out of that clay would crack when it was fired."**

In which sentence below is fired used with the same meaning as in the sentence above?

A) The teenager got fired from his job for being late.

B) The team was fired up after their big win.

C) The astronaut fired the engines at liftoff.

D) The chef fired the pizza in a hot oven.

2. Which step did Maria take *last* to create a new, shiny pot?

A) She polished the dried surface.

B) She glued the broken pieces.

C) She placed it in the fire.

D) She mixed clay and other items.

3. What would have most likely happened if the archaeologist had *not* come to Maria's village?

A) Maria would still have become famous.

B) Maria would have discovered the old pots herself.

C) Maria would have continued making regular pots.

D) Maria's family would not have continued making pottery.

4. Which of the following best describes hot this passage is organized?

A) sequential order

B) compare and contrast

C) proposition and support

D) cause and effect

Appendix C

SAT College Level Testing Prompt (Experiment 1)

In the 16th century, an age of great marine and terrestrial exploration, Ferdinand Magellan led the first expedition to sail around the world. As a young Portuguese noble, he served the king of Portugal, but he became involved in the quagmire of political intrigue at court and lost the king's favor. After he was dismissed from service by the king of Portugal, he offered to serve the future Emperor Charles V of Spain.

A papal decree of 1493 had assigned all land in the New World west of 50 degrees W longitude to Spain and all the land east of that line to Portugal. Magellan offered to prove that the East Indies fell under Spanish authority. On September 20, 1519, Magellan set sail from Spain with five ships. More than a year later, one of these ships was exploring the topography of South America in search of a water route across the continent. This ship sank, but the remaining four ships searched along the southern peninsula of South America. Finally they found the passage they sought near 50 degrees S latitude. Magellan named this passage the Strait of All Saints, but today it is known as the Strait of Magellan.

One ship deserted while in this passage and returned to Spain, so fewer sailors were privileged to gaze at that first panorama of the Pacific Ocean. Those who remained crossed the meridian now known as the International Date Line in the early spring of 1521 after 98 days on the Pacific Ocean. During those long days at sea, many of Magellan's men died of starvation and disease.

Later, Magellan became involved in an insular conflict in the Philippines and was killed in a tribal battle. Only one ship and 17 sailors under the command of the Basque navigator Elcano survived to complete the westward journey to Spain and thus prove once and for all that the world is round, with no precipice at the edge.

Appendix D

SAT College Level Reading Comprehension Test (Experiment 1)

1. The 16th century was an age of great ______ exploration.

A. cosmic
B. land
C. mental
D. common man
E. None of the above

2. Magellan lost the favor of the king of Portugal when he became involved in a political ________.

A. entanglement
B. discussion
C. negotiation
D. problem
E. None of the above

3. The Pope divided New World lands between Spain and Portugal according to their location on one side or the other of an imaginary geographical line 50 degrees west of Greenwich that extends in a _________ direction.

A. north and south
B. crosswise
C. easterly
D. south east
E. north and west

4. One of Magellan's ships explored the _________ of South America for a passage across the continent.

A. coastline
B. mountain range
C. physical features
D. islands
E. None of the above

5. Four of the ships sought a passage along a southern ______.

A. coast
B. inland
C. body of land with water on three sides
D. border
E. Answer not available

6. The passage was found near 50 degrees S of ________.

A. Greenwich
B. The equator
C. Spain
D. Portugal
E. Madrid

7. In the spring of 1521, the ships crossed the _______ now called the International Date Line.

A. imaginary circle passing through the poles
B. imaginary line parallel to the equator
C. area
D. land mass
E. Answer not available

Appendix E

SAT College Level Reading Prompt (Experiment 2)

Marie Curie was one of the most accomplished scientists in history. Together with her husband, Pierre, she discovered radium, an element widely used for treating cancer, and studied uranium and other radioactive substances. Pierre and Marie's amicable collaboration later helped to unlock the secrets of the atom.

Marie was born in 1867 in Warsaw, Poland, where her father was a professor of physics. At an early age, she displayed a brilliant mind and a blithe personality. Her great exuberance for learning prompted her to continue with her studies after high school. She became disgruntled, however, when she learned that the university in Warsaw was closed to women. Determined to receive a higher education, she defiantly left Poland and in 1891 entered the Sorbonne, a French university, where she earned her master's degree and doctorate in physics.

Marie was fortunate to have studied at the Sorbonne with some of the greatest scientists of her day, one of whom was Pierre Curie. Marie and Pierre were married in 1895 and spent many productive years working together in the physics laboratory. A short time after they discovered radium, Pierre was killed by a horse-drawn wagon in 1906. Marie was stunned by this horrible misfortune and endured heartbreaking anguish. Despondently she recalled their close relationship and the joy that they had shared in scientific research. The fact that she had two young daughters to raise by herself greatly increased her distress.

Curie's feeling of desolation finally began to fade when she was asked to succeed her husband as a physics professor at the Sorbonne. She was the first woman to be given a professorship at the world-famous university. In 1911 she received the Nobel Prize in chemistry for isolating radium. Although Marie Curie eventually suffered a fatal illness from her long exposure to radium, she never became disillusioned about her work. Regardless of the consequences, she had dedicated herself to science and to revealing the mysteries of the physical world.

Appendix F

SAT College Level Reading Comprehension Test (Experiment 2)

1. The Curies' _________ collaboration helped to unlock the secrets of the atom.

A. friendly
B. competitive
C. courteous
D. industrious
E. chemistry

2. Marie had a bright mind and a ______ personality.

A. strong
B. lighthearted
C. humorous
D. strange
E. envious

3. When she learned that she could not attend the university in Warsaw, she felt _________.

A. hopeless
B. annoyed
C. depressed
D. worried
E. None of the above

4. Marie _________ by leaving Poland and traveling to France to enter the Sorbonne.

A. challenged authority
B. showed intelligence
C. behaved
D. was distressed
E. Answer not available

5. _________ she remembered their joy together.

A. Dejectedly
B. Worried
C. Tearfully
D. Happily
E. Irefully

6. Her _________ began to fade when she returned to the Sorbonne to succeed her husband.

A. misfortune
B. anger
C. wretchedness
D. disappointment
E. ambition

7. Even though she became fatally ill from working with radium, Marie Curie was never _________.

A. troubled
B. worried
C. disappointed
D. sorrowful
E. disturbed

Appendix G

The Tablet Familiarity Questionnaire (Experiment 2)

For the following items, reflect on your personal familiarity with tablet computers. For each statement, please circle a response on a five-point scale with a one being "Strongly disagree" and a five being "Strongly agree".

1	**2**	**3**	**4**	**5**
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

1. I think tablet computers are easy to use.
   1 2 3 4 5
2. It is difficult to edit text by tablet computer.
   1 2 3 4 5
3. I do not know how to navigate information by tablet computer.
   1 2 3 4 5
4. I always try to get out by myself when in trouble with a tablet computer.
   1 2 3 4 5
5. I am skilled at using tablet computers to get in touch with my friends
   1 2 3 4 5
6. I'd like to try new apps on a tablet computer
   1 2 3 4 5
7. I do not know how to use a tablet computer to watch videos.
   1 2 3 4 5
8. I am skilled in using tablet computers to listen to music.
   1 2 3 4 5
9. I know how to download apps by tablet computer.
   1 2 3 4 5
10. I know how to uninstall apps on tablet computers.
   1 2 3 4 5
11. I know how to set up tablet computers into an existing network.
   1 2 3 4 5
12. I know how to update the OS and apps on a tablet computer.
   1 2 3 4 5
13. I know how to import files into a tablet computer.
   1 2 3 4 5
14. I know how to set up personalized settings on a tablet computer.
   1 2 3 4 5
15. I usually use a tablet computer.
   1 2 3 4 5

16. I always browse the web on a tablet computer.
1 2 3 4 5
17. I always use an e-Reader to read (such as Amazon Kindle)
1 2 3 4 5
18. I usually use tablet computers to read e-books.
1 2 3 4 5

19. I prefer using a tablet computer to a computer.
1 2 3 4 5
20. I already have a tablet computer.
1 2 3 4 5
21. I often use a tablet computer to listen to music.
1 2 3 4 5
22. I rarely use a tablet computer to watch videos.
1 2 3 4 5
23. I do not like listening to music on tablet computers.
1 2 3 4 5
24. I like logging in QQ and microblog on tablet computers.
1 2 3 4 5
25. I am a tablet computer gaming master.
1 2 3 4 5
26. I always use a tablet computer to play games.
1 2 3 4 5
27. I prefer to sue a tablet computer to play games.
1 2 3 4 5
28. I can get a tablet computer anytime I need.
1 2 3 4 5
29. I would buy a tablet computer anytime I need.
1 2 3 4 5
30. I always refer to help docs when being stuck with an app.
1 2 3 4 5
31. I always surf the internet to find out solutions when stuck.
1 2 3 4 5
32. I always try to restart the tablet computer when it crashes.
1 2 3 4 5