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Using the Cornell Note-taking System Can Help Eighth Grade Students Alleviate the Impact of Interruptions While Reading at Home

Bradley P. Evans
Shanghai American School

Chris T. Shively
State University of New York at Buffalo State

A large group of eighth-grade social studies students (N=-101) received instruction and practice using the Cornell note-taking system and were assigned to one of three note-taking groups or one non-note-taking group. Students were asked to read an article about persuasion and use their assigned note-taking system to take notes at home. A 10-question multiple choice reading comprehension test and questionnaire were given. A one-way ANOVA found a significance in the group's means and a Tukey HSD found significant differences between each note-taking group and the non-note-taking group. The students' self-reported feelings of preparedness, their time spent reading and taking notes, overall comments about their experience and their reporting of interruptions were analyzed using constant comparisons and questioning strategies. Two conclusions can be drawn from these results. First, middle school students must take some form of notes to benefit from the encoding process while reading. Secondly, middle school teachers should not fear giving their students reading and note-taking homework assignments. This study provides evidence that supports the idea that the Cornell system can be used to increase student confidence and alleviate the impact interruptions have on students' working memories while reading at home.

Introduction

The use of technology in the classroom is simultaneously crucial to the education of students and forever changing student learning behaviors. In a recent report by Project Tomorrow, one in three US students are currently using technology, such as laptops and tablets, issued to them by their school (The New Digital Learning Playbook, 2013). Researchers have been studying the consequences of teaching and learning with technology for decades (cf. Berson, 1996; Cuban, 1993; Mehan, 1989; Shively & Yerrick, 2014; Wartella & Jennings, 2000) and over the years, two popular models have emerged to foster our understanding of how to generate effective teaching with technology. One model, called the Technological Pedagogical Content Knowledge model (or TPCK), was designed to help educators visualize the relationships between technology, pedagogy and content (Koehler & Mishra, 2008). Another model, called the

Substitution, Augmentation, Modification and Redefinition Model (or SAMR), has been used to categorize instructional technology practices into 4 different tasks (Puentedura, 2012).

According to the SAMR model, technology can be used as an enhancement or as a transformation of teaching and learning. Teachers can enhance instructional and learning tasks when they use technology as a substitute for, or augmentation of, a task that could have been completed without technology. For example, if a middle school teacher required their students to read an article and type notes instead of writing them, the act of typing letters substitutes for writing them by hand and since a word processor is most likely to be used, the added functionality of spellcheck would augment the writing task. Technology can also transform the way in which tasks are completed in the classroom when they are modified or redefined using strategies that could not be done without the use of technology. In the note-taking example above, the teacher could modify the note-taking task for students who cannot type or write by using the audio recording features of a laptop (or tablet/phone). If the teacher wanted to redefine the note-taking task, they could ask that their students share their notes to an online classroom journal (using a software tool like Seesaw), have their students read their classmates' notes and finally have them modify their notes based on the shared notes. In the next section, we have used the SAMR model as a lens to view relevant research that supports our study of digital note-taking with 8th grade social studies students.

Note-taking Before the Computer Age

Before examining studies that describe the impact of students taking digital notes instead of handwritten notes, it is important to examine the early research about note-taking. Miller, Galanter and Pribram (1960) described note-taking as one step in the process of learning. They viewed the act of note-taking as an intentional plan to free up working memory by externally storing information that can be retrieved at a later time. This external storage function is quite beneficial to the process of learning, but it is not the only benefit to note-taking. Di Vesta and Gray (1972) insist that note-taking can facilitate the transfer of new material into long term memory when a learner creates a note by "acting on the incoming information, sifting out relevant material, and organizing important content" (p. 13). The transformation of new material into existing cognitive structures, or the essential mental processes learners use to comprehend material (Garner, 2007), has been called the encoding function of note-taking. The traditional

method of note-taking by hand, some call longhand (Mueller & Oppenheimer, 2014), usually entails a student being asked to read a passage or listen to a lecture and write down main ideas and other key information from the passage; this has happened in college, high school and middle school classrooms for decades. All this work by students is designed to induce a deeper understanding of and more factual recall of the information being learned (Faber, Morris & Lieberman, 2000).

In the 1970s and 80s, researchers began studying the two functions of note-taking with university students under laboratory conditions (Carter & Van Matre, 1975; Di Vesta & Gray, 1972; Einstein, Morris, & Smith, 1985; Peper & Mayer, 1978) and normal classroom conditions (Collingwood & Hughes, 1978; Fisher & Harris, 1973; Klemm, 1976). Conclusions drawn from these early studies confirm the notion that note-taking does serve two functions but the idea that one function is more important than the other function was not established. Kiewra (1989), in his analysis of these early studies, suggests that research has demonstrated that both functions are important to advancing student achievement, so it is not as important to prove one function is more important than the other. He believed that it was more imperative to study how students take notes and how they review their notes than to indicate which function was most indispensable to the learning process.

The push for this line of research may have occurred because several studies demonstrated that college-aged students are "generally incomplete note-takers" (Kiewra, 1987, p. 233), and therefore instructors needed to modify existing note-taking procedures in an effort to help students. Researchers have examined instructional interventions at the collegiate level such as cueing for critical ideas (Locke, 1977; Maddox & Hoole, 1975; Moore, 1968), altering the rate of lectures (Aiken, Thomas, & Shennum, 1975), and organizing the presentation of text materials (Annis, 1979). Although studies about note-taking interventions with high school and middle school students have been undertaken, the number of studies carried out at these levels is extremely limited compared to the number implemented with college students. Researchers have, however, evaluated the effects of using a pre-reading strategy before taking notes with high school English students (Hidi and Klaiman, 1983) and the impact of modifying the content and form of notes with middle school students (Faber et al., 2000; Risch & Kiewra, 1990).

As mentioned earlier, the extant literature about student note-taking before the computer age is abundant, especially studies conducted with college students. When professors and

teachers began to substitute, augment and modify the traditional note-taking practice of writing on paper with taking notes on a computer, a new line of research emerged.

Enhancing & Transforming the Note-taking Process with Computers

In an effort to maximize the amount of content they could deliver to 30 or more students in a single classroom, college professors and high school teachers developed a cultural tool (Stetsenko, 1999) called the lecture (Cuban, 1986). Lecturing provides educators with control of the content and the pacing of that content; it also requires students to take notes about that content. Many university-aged students began substituting paper notebooks for laptop computers in the early part of the 21st century and started using them to take notes while listening to lectures. This new way to generate and store notes caused several researchers to begin examining the effects of using a computer to take notes.

Several studies have revealed how typed notes, when used as a substitute for handwritten notes, effect the note-taking process and student learning. Computers have caused students to generate larger quantities of notes when they typed instead of writing by hand (Bui, Myerson, & Hale, 2013; Mueller & Oppenheimer, 2014; Peverly, Ramaswamy, Brown, & Sumowski, 2007). Due to the encoding and external functions of note-taking, typing notes on a computer has been shown to reduce the seductive details effect, or the students' exposure to unimportant details (e.g. images) that increase the cognitive load embedded in a lecture presentation, with a group of Chinese undergraduates (Wang, Sundararajan, Adesope, & Ardasheva, 2017). Taking notes on a computer also did not negatively impact the grades of undergraduate biology students; they performed as well on exams as students who hand wrote notes on paper (Aguilar-Roca, Williams, & O'Dowd, 2012). Educators and researchers have also transformed the note-taking process in their classrooms by using the functionality of computers to the benefit and detriment of students.

L. Brent Igo is the lead author of a sequence of studies where teachers transformed the structure and method of the note-taking process to take advantage of the functionality computers. Igo and his colleagues examined the effects of using a note-taking tool that resembled a chart (matrix) with university and high school students. They also studied the effects of note-taking with a chart with middle school students with learning disabilities. The researchers created the chart in a word processor and students used it to take notes on a computer under three conditions. Students: 1.) typed notes into the chart's cells, or 2.) they copied/pasted (CP) words into the cells,

or 3.) they CP a restricted number of words into the cells. According to Igo, Bruning, & McCrudden (2005) option three (the restricted word version), "… was designed to encourage evaluative note-taking decisions by limiting the amount of information that students could CP into each cell …" (p. 104). In other words, Igo et al. wanted to examine the encoding function of note-taking because students who had to CP a restricted number of words for their notes would be actively placing new material into long-term memory (DiVesta & Gray, 1972) because they would have to selectively organize the material that made sense to them (Peper & Meyer, 1978).

The chart or matrix model was first tested with undergraduate educational psychology students. When these students entered notes into the matrix, those students who used the restricted word version recalled more facts, recognized more concepts and made more inferential relationships between concepts than their unrestricted colleagues (Igo et al., 2005). Igo and Kiewra (2007) asked high achieving university and high school students to use the matrix in a similar manner. The researchers found that the note-taking conditions did not impact the results when high achieving students used the matrix; the students learned the same amount of information. With that said, an interesting and unexpected phenomenon did materialize. Igo and Kiewra's data showed that high-achieving students in the unrestricted note-taking condition strategically restricted their CP notes, even though they were not asked to, which was a clear indication that they were engaged in selectively organizing the material, or encoding, the material. This transformed note-taking method, developed because of the functionality of the computer, caused encoding to occur with older and high achieving students; this was not the case with middle school students.

Two studies conducted with middle school students with learning disabilities (MSSLD) did not produce the same conclusions regarding the encoding function of note-taking described in the preceding paragraph. Igo, Riccomini, Bruning, & Pope (2006) asked MSSLD to use a paper chart (matrix) format used in the studies with the university and high school students. The researchers discovered that typing caused considerable problems for these students. The students said that they did not like to type because they did not know where the keys were so they had to keep looking away from what they were learning in order to type notes, this gave many of them stress and anxiety. Typing also revealed spelling and grammatical errors that contributed to their anxiety. The students preferred taking notes using the CP method and the data showed that this method enabled them to perform better than students who wrote or typed their notes on a

multiple-choice test given immediately after taking notes. The CP method, however, did not lead to a deep processing of the content as demonstrated on the delayed recall and multiple-choice tests.

Igo, Bruning, and Riccomini (2009) eliminated the note-taking method of typing based on the qualitative results of Igo et al.'s 2006 study. The MSSLD in this study, who CP their notes into the matrix performed better on the delayed recall and multiple-choice tests; this result was not the same as the 2006 result. Igo et al. (2009) attribute this finding to the students' being asked to review their notes prior to taking the delayed tests and the students' ability to read the CP notes better than their written notes. The researchers deduced that the act of deciphering one's handwritten notes may have produced an extraneous cognitive load on the students while they reviewed their notes. Despite this negative experience, many researchers have found that taking notes by hand can be used to improve learning.

Paper Note-taking During the Age of the Computer

In the previous section, we described studies where the note-taking process was enhanced and transformed by the functionality of the computer, and in many cases, was beneficial to the students. However, in many of the aforementioned studies, researchers also learned that taking notes on the computer by university-aged students can lead to a shallow processing of information and a tendency to engage in non-academic computing tasks such as visiting non-educational Internet sites (Aagaard; 2015; Aguilar-Roca et al., 2012; Fried, 2008; Kraushaar & Novak, 2010; Ravizza, Uitvlugt, & Fenn, 2016). Researchers also found that students complained that other students' off-task computer behaviors in the classroom distracted them from learning (Aagaard; 2015; Aguilar-Roca et al., 2012; Fried, 2008). Obviously, there are pros and cons to using computers to take notes, so perhaps educators should ask their students to start taking notes with paper again. But is paper a viable solution?

Note-taking with Paper

In most of the studies described in the "Enhancing & Transforming the Note-taking Process with Computers" section of this paper, researchers compared the effects of taking notes on paper with taking notes on the computer. They uncovered some promising results for advocates of taking notes on paper. College biology students who took notes on paper during the

course of a semester achieved more As than students who took only notes on their computers (Aguilar-Roca et al., 2012). Preservice teachers, who participated in a study about the role of note-taking in distracting environments, performed better on a word recall test when they took notes on paper while in a controlled, non-distracting environment (Lin & Bighenho, 2011). University students who took notes on paper, in any format they preferred, performed better on factual recall and conceptual understanding tests than their fellow students who took notes with the computer (Mueller and Oppenheimer, 2014). The benefits of taking notes on paper was also seen in studies with middle school students with learning disabilities. When MSSLD completed a note-taking matrix on paper, they recalled more ideas on an immediate recall test than students who CP their notes (Igo et al., 2006; Igo et al., 2009). Taking notes on paper was found to increase the encoding skills of paraphrasing, summarizing, selecting and organizing and it also appears to help students with some tasks and in some learning environments, but not with others.

Purpose of Research

In all of the computer-based, note-taking studies we analyzed, researchers used the computer to enhance and/or transform the note-taking process. Most of the studies were conducted with university-aged or high school students who took notes about a lecture, a PowerPoint presentation or electronic text. Those studies conducted with middle school students investigated the effects of note-taking with students with learning disabilities and not general education students. All of the studies were conducted in "lab-type settings" or in classrooms (lecture halls). None of the researchers examined the effects of taking notes about an electronic text using different formats and from the students' homes.

The research we presented indicates that it is possible for students to take notes effectively using a computer in the classroom (or in a controlled lab setting), but we do not know about the positive and negative impacts of note-taking on the retention of information when notes are taken at home and with middle school students. Middle school students are inexperienced with note-taking and their handwriting ability/legibility can decrease at this age (Igo et al., 2009). According to Faber et al. (2000), ninth graders are only on the verge of being able to capitalize on the encoding function of note-taking, so does that mean that encoding is unattainable for younger students? These three realizations hint towards the need for educators

to provide guided notes and to critically examine the results of typing notes instead of writing them.

The "genie is out of the bottle" in the sense that schools and most homes cannot go back to a day sans technology. In a 2015 study, Lenhart found that 73% of US teens, ages 13 - 17, owned a smartphone and 87% had access to a desktop/laptop computer. Teachers feel more comfortable asking teenagers to read digital text and take notes about that text outside of school as more families have computers at home (Anderson, 2015). Students read and write on computers, tablets and phones, categorized as Internet Connected Devices (IcD), that are bombarded by notifications from email, news feeds, and social media. These notifications cause interruptions that may leave some students with: 1) the feeling of being unfocused; 2) an increase in stress that can lead to impaired working and long-term memory; and 3) a feeling of not being in control of one's actions, commonly referred to as "learned helplessness" (Klingberg, 2008).

The first author is a Social Studies teacher who teaches in a 1-1 classroom, which is a classroom where every student has their own digital device for school. As mentioned previously in the Project Tomorrow study, these types of learning environments are growing; in fact, in the first author's most recent school year, he taught in a 2-1 environment, meaning students had two technology devices for learning per student. In his 1:1 classroom, students are often asked to engage in nonfiction reading, to read for understanding and to think critically of the information they are consuming. When readings are assigned, students take notes using a strategy to aid their comprehension and as a formative tool for their teacher to assess their understanding. Students in his classroom inevitably ask if they can take their notes digitally instead of by hand, a phenomenon studied by Aguilar-Roca et al. (2012) in a university level biology course.

The first author's experiences in allowing his middle school students to type their notes, as opposed to writing them long hand, has been a frustrating myriad of student conversations and results. It should be noted that these observations occurred while his students took notes in the classroom. An informal analysis of digital note taking in his classroom led to the following 4 observations: 1) Students prefer to take notes digitally because that is a major part of their social selves and it is also viewed as easier; 2) Notes taken digitally are often wordier, less substantive, and do a poorer job of identifying the key aspects of the reading. This observation is aligned with previous researchers who have identified the same phenomena (Bui et al., 2013; Mueller & Oppenheimer, 2014; Peverly, et al., 2007); 3) Notes taken digitally often have large chunks that

are copy/pasted which could lead to limiting encoding and shallow processing (2014); and 4) students are often easily and frequently distracted when using their laptops/tablets. This was also found to be true with university students (Aagaard; 2015; Aguilar-Roca et al., 2012; Fried, 2008; Kraushaar & Novak, 2010; Ravizza, et al., 2016).

If students exhibit signs of shallow processing while taking notes in the classroom, what would their processing of reading material look like if they read at home?

The Present Study

The study took place over the course of three weeks with eighth grade social studies students in a middle school in the first author's classroom and the homes of his students. The research we reviewed earlier in this paper described note-taking studies that took place in classrooms or lab settings, and in almost all cases, they occurred at the university level. This study is unique in that we examined the effects of taking notes by hand or on the computer in the context of the middle school students' homes. Since it was established by the first author that his students demonstrated signs of shallow processing while taking notes without a system in the classroom (arguably a controlled context), we wanted to investigate the effects of his students using a systematic note-taking system in an uncontrolled context, the students' homes. Context was very important to us because children "shape and are shaped by the individuals, tools, resources, intentions, ideas in a particular setting, within a particular time" (Graue & Walsh, 1998, p. 11).

Participants and Site

The participants in this study were 101 eighth-grade students from a K - 12 Chinese international school that serves a population of around 1700 students. The eighth grade students represented the general school wide demographics in nationality: 46% American, 19% Other, 12% South Korean, 9% Canadian, 8% Hong Kong and 6% Taiwanese. Many of them are bilingual and nearly 44% of the students speak Chinese as their first language. Students and parents were given an informed consent letter to sign, told that participation in the study was voluntary and that lack of participation would not affect their social studies grade.

The school followed a double block schedule, which means that students attended their content area classes (like Social Studies) every other day because the class periods were twice as

long as a traditional class period. The first author taught four classes, roughly equal in size and demographics, and met with two of the four classes each day.

A purposeful sample of convenience, using homogenous and maximal variation sampling (Creswell, 2015), was used to select participants from the four social studies classes. Homogenous sampling occurred because all of the participants learned in a 1:1 computing environment and routinely read material using some form of electronic media during class. Maximal variation sampling took place naturally, as the social studies classes were already divided into four distinct groups, roughly equal in gender, English speaking as a second language and ability.

As stated earlier, the middle school students in this study preferred to take notes digitally and often these notes were just copied and pasted from the digital text. As Kiewra (1987) noted, students are often incomplete note-takers, so to combat this problem, students were taught the Cornell note-taking system. All students were taught how to use the note-taking system during their regular Social Studies class time. They learned about the three sections of the system (notes, questions, summary), were provided with guided practice during class time, and were given feedback about how to avoid common note-taking pitfalls.

Cornell Note-taking System

The Cornell note-taking system provides students with a way to engage in a "completely natural learning cycle" (Pauk, 1997, p. 206) using the same document. The learning cycle begins when a note-taker formats a document into three unequal sections. First the note-taker draws a vertical line on the left side of the document about 6 cm (about 2.25") from the edge and stops about 5 cm (about 2") from the bottom; this line creates a section called the cue column. Next, the note-taker draws a horizontal line across the width of the document about 5 cm from the bottom; this section is called the summary section. The two perpendicular lines leave the note-taker with a large section used for taking notes. According to Pauk (1997), the note-taking system is a natural learning cycle because it requires the note-taker to record, review and assess one's understanding of new information all while interacting with a single document. The following scenario describes the "natural learning cycle" that a note-taker would use with the system.

During a lesson, the learner (note-taker) captures ideas from a lecture or a reading in the note-taking section. After the lesson, the learner: 1) reviews and clarifies poorly written/typed words and revises misspellings; 2) writes questions about the main ideas of the notes in the cue column; 3) covers up their notes and answers the questions they just wrote (or uncovers their notes when an answer cannot be provided); 4) writes a summary consisting of one to two sentences in the summary section; and 5) uses the external storage function of the system to review their notes by themselves or with classmates at a later date.

Instructional description. Students practiced using the Cornell note-taking system in class for two weeks. At the conclusion of the second week, students were given a reading assignment to be completed at home and were instructed to use the note-taking system, on paper, while reading. This practice assignment was very similar to the type of activity that the students would eventually complete for the study. When the students returned to class, they handed in their notes and were provided with feedback regarding how well they used the system. Common student errors included: notes sections that had few notes, notes taken in paragraph form, questions that were closed ended or yes/no questions and summaries that were far too long. Students were told to use the feedback to help them use the system more efficiently in the future.

Reading assignment for the study. Students in each of the four classes were randomly split into four different note-taking groups (see Table 1 for descriptions) and given a short article to read for homework about the psychology of persuasion. The article was taken from the students' psychology textbook and was used to introduce the students to the basics of persuasion. It was 1,629 words long with a Flesch-Kincaid reading grade level (Solnyshkina, Zamaletdinov, Gorodetskaya, & Gabitov, 2017) of 9.6. Students were told that they would use the article's information to help them plan and give a persuasive sales pitch to the class at the conclusion of the economics unit they had just started. The article was distributed in PDF format using the school's learning management system Schoology.

Table 1. Description of Note-taking Systems and Student Groups

HCN	Handwritten Cornell Notes: Students were instructed to use the Cornell note-taking system to take notes in their notebooks. They were reminded to take notes about the main ideas presented in the reading and to take only one or two bulleted notes for every one to two paragraphs.
TCN	Typed Cornell Notes: Students were instructed to use the Cornell note-taking system to take notes on their computers. They were reminded to take notes about the main ideas presented in the reading and to take only one or two bulleted notes for every one to two paragraphs.
PN	Personal Notes: Students were instructed to take notes using whatever note-taking method they preferred.
NN	No Notes: Students were told not to take any notes while reading. This group acted as the control group.

Students were told that when they returned to the following class, they would be given a 15-question survey to help the research team gain insight into their perceptions of using or not using a particular note-taking system. They were also given a 10-question, researcher generated, multiple choice reading comprehension test to assess their understanding of the persuasion article. To help eliminate grade anxiety for the non-note takers, students were told that they would be able to retake the test at a later date. The multiple-choice questions were similar to the following example:

It's Tuesday and Huey wants his brother to do his weekend chores for him so he can go out with friends. Huey tells his brother Steve that he'll help him with his homework after dinner if Steve promises to do Huey's weekend chores. Before Steve can respond, Huey says that he'll also clean the dinner dishes for Steve that night too. Steve says yes to doing his brother's weekend chores. Huey used the _____ technique of persuasion?

(a.) door-in-the-face technique

(b.) that's-not-all technique

(c.) foot-in-the-door technique

(d.) low-ball technique

In an effort to see if the four classroom-based observations would manifest themselves in the students' homes, a mixed methods study was designed to compare the reading comprehension scores of eighth grade middle school students who took notes using different

systems at home and to investigate the students' perceptions about taking notes at home, a place with the potential for different interruptions than in school. We asked the following two questions:

1) How do students who use the Cornell note-taking system differ on a delayed reading comprehension assessment from students who do not take notes or who use their own note-taking system?

(2.) What do students self-report about their reading and note-taking experience at home?

Data Analysis

Quantitative data analysis. Quantitative data were analyzed using descriptive statistics. The measures of central tendency and variability in the data set were reported with a box-and-whisker plot. This summarization tool also revealed the outliers in the data. Outliers were defined as data points that were 1.5 times the height of the interquartile range. Identified outliers were removed from the data set prior to statistically analyzing the data because outliers create skewness and other problems for researchers (Huck, 2008). A one-way analysis of variance with a Tukey HSD (Honestly Significantly Different) post-hoc analysis was computed to determine if there was a significant difference between the comprehension score means of each note-taking group.

Qualitative data analysis. Qualitative data were analyzed using the Grounded Theory method. Questionnaire responses were initially read without performing any analysis and then re-read using Corbin and Strauss's (2015) questioning strategy to help us view the students' responses from their perspective. Questioning the students' responses enabled us to make comparisons, identify relationships, see patterns, and categorize the data with similar properties. The categories were used to make claims about the data.

Analyzing the quality and quantity of the students' notes was outside the scope of this study and is a limitation of this study.

Results

As mentioned earlier, eighth grade students in the first author's classroom preferred taking digital notes, but said that they were frequently distracted while doing so. Their notes were often wordy, appeared to be copied and pasted from the text they were reading and often

failed to describe the main ideas. These poor note-taking behaviors caused the first author to transform the note-taking process by teaching his students how to use the Cornell note-taking system on the computer. This pedagogical move can be categorized as a modification when viewing it through the lens of the SAMR model. In this section, we compare the reading comprehension scores of the note-taking groups.

Research question #1: How do note-taking groups differ on a delayed reading comprehension assessment?

We hypothesized that students using the Cornell note-taking system would outperform the students who used a personal note-taking system and those who did not take notes on a post-reading comprehension test. This hypothesis was formed because note-taking with the Cornell-system facilitates the transfer of new material into existing cognitive structures, or schemas, (DiVesta & Gray, 1972) due to the design of the system (cueing column, notes, and summary section). This design causes the note-taker to deliberately regulate several cognitive tasks simultaneously (Piolat, Olive, & Kellogg, 2005) and allows for the interaction of long-term memory schemas with the new material brought into working memory (Paas, Renkl, & Sweller, 2003). Note-takers have to regulate their comprehension of what is being read (asking questions such as: do I understand what I am reading) and select what they judge to be the key ideas and details that should be written/typed into the notes section. As seen in the box-and-whisker plot in Figure 1 and the explanations below it, this hypothesis was confirmed.

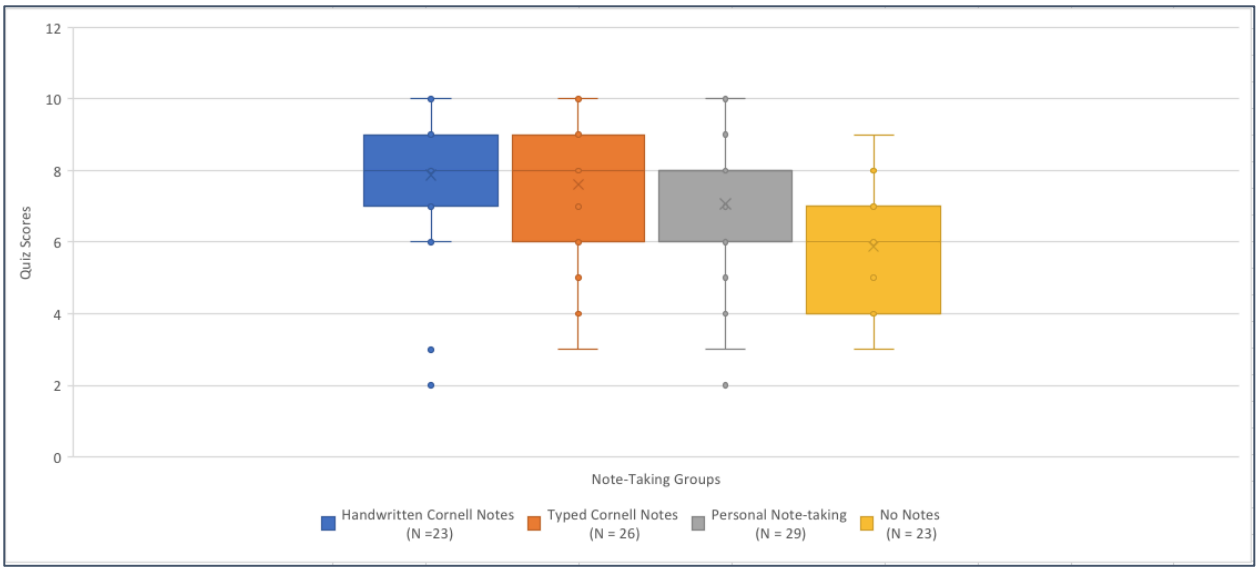

Figure 1. Box-and-Whisker plot of reading comprehension scores (N=101). Boxes enclose the middle 50% of values or the Interquartile range; the "X" in the box indicates the mean for each group; extending lines indicate the top 25% and bottom 25% of values; outliers are indicated with dots.

On the reading comprehension test, students who took some form of notes performed similarly well and outperformed students who did not take notes. The mean for all students (N=101) was 7.12, with a scoring range between 2–10. Figure 1 displays the distribution of the scores, the means (indicated by an "X" inside the box), the minimum and maximum scores and the outliers. The mean (*M*) and interquartile range (IQR) for the Handwritten Cornell Notes (HCN) group was *M*=7.87, IQR=2.0; for the Typed Cornell Notes (TCN) group was *M*=7.61, IQR=3.0; for the Personal Notes (PN) group was *M*=7.07, IQR=2.0; and for the No Notes (NN) group was *M*=5.87, IQR=3.0. Excluding the outliers, 80.95% of the students in the HCN group scored above the mean (73.91% with the outliers), 61.54% for the TCN group, 53.57% for the PN group (51.72% with the outlier) and 52.17% for the NN group. There was a noticeable difference in means between the note-taking and no note-taking groups, so a one-way analysis of variance (ANOVA) was performed to compare the means of the comprehension test scores at an alpha level of 0.5.

As we described earlier, the box-and-whisker plot was used to identify outliers, so that they could be removed from the statistical test (Huck, 2008). Scores were removed that were 2 standard deviations from the mean; this phenomenon occurred in the HCN (2 scores) and PN (1 score) groups (see Figure 1). The one-way ANOVA results, viewed in Table 2, suggested a statistically significant difference between one or more groups; therefore, we rejected the null

hypothesis (that all 4 mean scores would be equal) and examined the differences between groups with a Tukey HSD post-hoc test. This test revealed a significant difference between the HCN and the NN group ($p < 0.01$), the TCN and the NN group ($p < 0.01$), and the PN and NN group ($p < 0.05$). No significant differences were found between the note-taking groups.

Table 2. Results for a One-Way ANOVA of the Differences in Achievement on a Comprehension Test

Sources of Variation	*df*	*Mean Squares*	*F Ratio*
Between Groups	3	24.71237269	8.387210226*
Within Groups	94	2.946435348	

*p < .05

The Mueller and Oppenheimer (2014) study highlighted the importance of notes that are purposeful if the goal is to aid in learning and the reading comprehension test results in this study reinforced their finding. The note-taking groups outperformed the no note-taking group as we expected. The HCN group outperformed all other groups when mean scores were compared and this result was similar to the two studies involving university students where students who took notes on paper outperformed students who took notes on the computer (Aguilar-Roca, et al., 2012; Mueller & Oppenheimer, 2014). Although there was a significant statistical difference between the note-taking and no note-taking groups, there was not a significant difference between the note-taking groups. Therefore, given the secondary benefits of using a computer (student organization, research capability, multimedia production, etc.), it could be argued that using a computer to transform a traditional paper note-taking system is a worthwhile pursuit, especially when a teacher supported note-taking system that provides guidance and purpose like the Cornell system is used. In conclusion, we found that middle school students can effectively take notes on the computer and use those notes to prepare for a reading comprehension test. In the next section, we use the students' self-reporting behaviors to explain these results.

Research question #2: What do students self-report about their reading and note-taking experience at home?

We felt it was important to capture all of the students' self-reported perceptions of their experience of taking notes at home in an anonymous manner; thus, the use of the questionnaire

instead of interviews. The use of Likert scales on the questionnaire enabled the students to turn abstract ideas, such as preparedness and time spent on a task, into numbers. We used those numbers to see how the students constructed their experiences and to identify trends in the data (Bogdan & Biklen, 1997). It was imperative that we explain the results of the comprehension test using the students' voices, in addition to citing the literature, because their words provided us with valuable insights into the mental processes that created (Wertsch, 1993) their note-taking experiences while at home. In this section we make two assertions about our data that explain the significant differences found in reading comprehension test results.

Assertion #1: Students from the Cornell note-taking groups felt more prepared for the reading comprehension test than the other two groups.

Assertion #2: Using the Cornell note-taking system can help eighth grade students alleviate the impact of interruptions upon their memory systems.

Assertion #1: Students from the Cornell note-taking groups felt more prepared for the comprehension test than the other two groups.

Taking effective notes means that notes are recorded and organized so that they may be used for review at a later time. Effective note-taking also means that note-takers must first comprehend the text, paraphrase, summarize, select & organize and then write down ideas from the text so that they can pass into long-term memory (Piolat et al., 2005). These notes must be understandable to the note-taker or confusion will occur and cause the note-taker to revisit the material and spend more time with the material, or stay confused. The Cornell note-taking system was designed to facilitate effective note-taking and has been shown to be successful with ninth grade students who used a paper version of the system (Faber et al., 2000). One of the goals of our study was to examine the effectiveness of the Cornell system with eighth grade students and we started this examination with the students' perceptions of their preparedness (or perceived self-efficacy) for the reading comprehension test.

According to Bandura (1982), perceived self-efficacy is the "… judgements of how well one thinks they can execute a course of action required to deal with prospective situations" (p. 122). In our study, students read an article about persuasion and used an assigned note-taking system to help them understand the text. The students' perceived self-efficacy of how prepared they felt before taking a reading comprehension test was measured on a questionnaire by a 5-

point Likert scale with 5 meaning most prepared for the comprehension test and 1 meaning least prepared. We expected that students who self-reported that they felt most prepared would come from the HCN group based on the university studies describing the benefits of taking notes by hand (Aguilar-Roca, et al., 2012; Mueller & Oppenheimer, 2014). We also expected the non-note-taking students (NN) would report that they felt the least prepared. Both of these expectations were met, but we did not expect there to be such a large gap between the HCN, TCN and PN students who felt they were the "most prepared."

Students from the HCN group self-reported that they felt more prepared for the reading comprehension test than their peers. A higher percentage of students in the HCN group described themselves as being at the "most prepared" level for the comprehension test than the other groups. In fact, the actual number of HCN students at a level "5" was also higher than in the other groups (HCN: 6, TCN: 4, PN: 3, and NN: 0). When columns 5 and 4 from Table 3 were combined, the note-taking group percentages were closer to each other (HCN: 56%, TCN: 50% and PN: 45%) but the gap between the note-taking groups and the NN group (NN: 13%) was still quite large. Table 3 displays a percentage of how the students felt about their preparation for the reading test; percentages were used instead of actual numbers because the number of students in each group was not equal.

Table 3. Percentage of Students Who Self-Reported Feeling Prepared for the Comprehension Test

	Self-Reported Preparedness (SRP) Scale*				
Note-taking Group	5	4	3	2	1
HCN (N=23)	26%	30%	26%	13%	4%
TCN (N=26)	15%	35%	39%	12%	0%
PN (N=29)	10%	35%	41%	14%	0%
NN (N=23)	0%	13%	22%	39%	26%

N = 101
*5 = most prepared, 1 = least prepared

Students who felt the "least prepared" ("1") came from the NN group (26%). When columns 2 and 1 were combined, the NN group had the largest percentage of students feeling "least prepared" (65%) followed by the HCN, PN and the TCN groups (17%, 14% and 12%). It is interesting to note that none of the students from the TCN and PN groups self-reported feeling "least prepared" (0% respectively) and 4% of the students in the HCN group (which was equivalent to 1 student) felt this way. It is more than likely that the 1 student in the HCN group who self-reported that they felt "least prepared" was one of the two HCN outliers shown in the box-and-whisker plot (see Figure 1). Although we had no way of knowing for sure if this student was an outlier, we came to this conclusion because of what the student reported on the questionnaire when they wrote, "Harvard note taking was a more efficient way of note taking" and that the "The content was boring" (HCN student quote).

The students in the Cornell note-taking groups felt more prepared than the personal and non-note-taking groups. One reason they may have felt more prepared was because they spent more time on the reading and note-taking tasks than the other groups and understood the two functions of note-taking.

The Cornell note-taking groups spent more time on the reading and note-taking tasks than the other groups. In DiVesta and Gray's (1972) view, the actions of note-taking and reviewing one's notes function as learning aids that facilitate the encoding process and enable one to learn new material. As we mentioned earlier, the Cornell note-taking system was designed to be such a learning aid, so we were not surprised that students who did not use the system spent less time on the homework task than those who used it. When students were asked how much time they spent on the article, 22% of the HCN students reported they spent over 30 minutes and this was noticeably different from the other groups (HCN: 22%, TCN: 8%, PN: 3% and NN: 0%). When we combined the first two columns of Table 4, 61% of the students from the HCN group spent 20 or more minutes on the task, which again, was in stark contrast to the other groups (HCN: 61%, TCN: 35%, PN: 20% and NN: 9%). When we combined the "10 – 20 minute" and "less than 10 minute" columns, 91% of the NN students spent less than 20 minutes on the task; again, this result was considerably different from the other groups (HCN: 39%, TCN: 65%, PN: 80%, NN: 91%). Table 4 displays self-reported times spent reading and taking notes organized by group.

Table 4. Percentage of Students Who Self-Reported Time Spent Reading and Taking Notes Organized by Note-taking Group

	Self-Reported Time			
Note-taking Group	t > 30	20 < t < 30	10 < t < 20	t < 10
HCN (N=23)	22%	39%	26%	13%
TCN (N=26)	8%	27%	50%	15%
PN (N=29)	3%	17%	72%	8%
NN (N=23)	0%	9%	48%	43%
N = 101 t = time				

Since we determined that the students who used the Cornell system spent more time reading and taking notes, we wanted to know about their experience and the experiences of the students who used a personal note-taking system and who did not take notes. Students in the TCN and PN group were not told that they could not copy/paste information from the article, so the large difference in percentages between note-taking groups could be attributed to their use of this digital note-taking strategy. Since we did not evaluate the students' notes, we had no way of knowing if copying and pasting was related to time spent taking. We used the students' comments to help us make sense of their note-taking experiences and the meanings they placed on those experiences (Seidman, 2103). Like Riessman (1993), we believe that meanings are transmitted through stories, in this case student comments from the questionnaire, and that people tell stories because they want to be known in a certain way.

Time spent over 30 minutes. Only four of the eight students who spent over 30 minutes on the task contributed comments. Four of the students from the HCN group chose not to provide any comments, so it was not possible to understand their actions. One might assume that the students who spent more than 30 minutes on the task were heavily involved in encoding the article's information and probably should have felt "most prepared" for the comprehension test, but their comments from the questionnaire did not corroborate this assumption. Those who replied were: confused about what to record, bored, dispirited by the design of the Cornell system and distracted by the technology while taking notes with it.

> *I need help on uncovering which pieces of text from an article/newspaper etc. is important to note down and which are not*. (TCN student, SRP: 4)
>
> *Halfway through the reading I became bored and went to play some violin. This helped me regain my focus*. (TCN student, SRP: 3)
>
> *Cornell notes seem pointless because writing questions just wasted time and the left side of the Cornell notes don't have as much space as I would like so I have to cramp the writing*. (HCN student, SRP: 3)
>
> *I get easily distracted when I was reading this article, swiping screens back and forth. On the other hand* [sic] *I chose Harvard Notes for my note taking strategy since I figure this note taking strategy is much more organized than the others*. (PN student, SRP: 3)

Based on these comments, students who spent more than 30 minutes on the tasks experienced problems taking notes and a note-taking system. None of these students described the two functions of notes and only the comment from the second TCN student found the Cornell system useful.

Time spent between 20 – 30 minutes. Sixteen out of 27 students chose to provide us with comments about their experience and six of those students gave us opinions about note-taking instead of describing what they did during the 20 – 30 minutes. They opined on the brevity of the article and why that feature did not cause them to be distracted (HCN student, SRP: 2; TCN student, SRP: 3), the benefits of learning how to take notes for their future in college (HCN student, SRP: 4), how they should be taught to take concise notes instead of a note-taking system (HCN student, SRP: 5) and that they preferred: to not use the summary section of Cornell notes (HCN student, SRP: 5), to take notes by hand but not with the Cornell system (HCN student, SRP: 3) and to be given a choice about whether or not they should take notes (NN student, SRP 1).

One opinion, from a student who took notes using their own preferred method (PN group), stood out from the rest of the students because they felt that taking notes did not enable them to process the information completely,

> *One of the flaws in taking notes is that people might overly rely on their notes. For example, for the assignment I just finished taking the notes and moved on to another assignment because I thought that I could always review it. However, I didn't. Without notes, I am more likely to make sure that I understood the content. With the notes, I*

> *always thought that they were always there even though I might not have actually processed the information fully*. (PN student, SRP: 3)

Again, since we did not analyze the students' notes, it was difficult to know how this student took notes. Since they indicated on the questionnaire that they preferred to use a computer to take notes using their own note-taking system, we deduced that this student may have used the computer to take notes by highlighting, copying/pasting or by typing. In all three instances, they may have only taken verbatim notes and as Igo and Kiewra (2007) pointed out, verbatim note-taking leads to shallow processing. Verbatim note-taking may have also caused one TCN student (SRP: 2) to "… forget the main gist about the article…" and caused them to "… reread the whole article again."

Seven of the 16 students who responded on the questionnaire chose to tell us that the Cornell note-taking system helped them understand the text better because they were able to capitalize on the functionality of the system's design. All but 1 of the 7 students came from the TCN group, which surprised us. The Cornell system provided students with sections to write notes, ask questions and summarize what they have learned so that the ideas could be reviewed at a later time. These sections lightened the load on the students' working memories (Miller et al., 1960) and we believe may have helped students overcome the interruptions they encountered at home. The students said,

> *The summary portion of the Cornell Note Taking technique helped me reflect. It also gave me a clear overview of what I learned*. (HCN student, SRP: 5)
>
> *I really liked the digital Cornell strategy, it was one of my first times using it (I was an exec) and I think it worked quite well. It was efficient as it was done digitally, while still making me stop and look back at the notes taken to create questions, a summary, etc. I think I will definitely be using the digital Cornell note taking method in the future*. (TCN student, SRP: 5)
>
> *If we could find a note taking strategy that is more engaging, it would be better. However, Cornell notes gives you multiple chances to review your notes, and thats [sic] a positive*. (TCN student, SRP: 4)
>
> *Cornell notes can be really helpful for reviewing notes several times*. (TCN student, SRP: 4)

> *That after taking notes we compare them to a partners [sic] opinion and explain why*. (TCN student, SRP: 2)
>
> *i [sic] feel like the cornell notes really helped me understand the text better compared to regular note taking*. (TCN student, SRP: 5)

Based on these comments, students in the TCN group explained how the Cornell system was used during their time reading and taking notes, while the other students offered teaching suggestions.

Time spent between 10 – 20 minutes. A very small percentage of students (26%) who spent 10 – 20 minutes reading and taking notes presented us with comments. And only three students thought the Cornell system was helpful, and of the three, just two referenced at least one of the two functions of notes.

> *Taking Cornell Digital Notes was very helpful because it allowed me to summarise* [sic] *my notes and re-read them to know what I wrote*. (TCN student, SRP: 4)
>
> *In my opinion, I don't think that the 'questions' part of the cornell notes while reading is helpful, but the 'summery' part of Cornell notes is*. (NN student, SRP: 2)
>
> *I think cornell notes is the way to go, it is very helpful*. (TCN student, SRP: 5)

Two students from the personal note-taking group felt that learning a note-taking system from a teacher was important for their future and the use of a technological note-taking system can help students with poor handwriting,

> *I believe right now, using personal note-taking strategies are fine, but later on when there is harder reading comprehension, we need to use a professional note-taking technique to maximize efficiency. This is why we need to be taught these methods now, to get used to them and so that we are more comfortable later on*. (PN student, SRP: 5)
>
> *Even though I think that hand written notes help us remember the content more, however it may be hard to review as the notes may not be as organized and categorized as digital notes can be. Therefore, I would prefer teachers' guidance for note taking strategies*. (PN student, SRP: 2)

and another PN student thought it was important to learn about the Cornell system, but teachers should allow students to take notes according to what the student thinks works best for them,

> *I think that its* [sic] *good to teach kids how to take notes but also allow them to choose what works best for them as we all learn differently. For example, for me handwritten*

> *notes are best because I can physically rewrite and think over what I had just learned and it helps me remember the content better*. (PN student, SRP: 5)

Other students also cited personal note-taking preferences because the system got in the way of their learning or that teachers should respect differences,

> *I personally prefer using my own strategy because it is what helps me learn and understand the best. I do not like using note taking methods assigned to me because then I focus more on how to take notes "properly" instead of taking efficient notes and understanding the reading*. (PN student, SRP: 4)
>
> *I felt that I was caught up in the note taking and not gaining a lot of knowledge along the way*. (PN student, SRP: 2)
>
> *Everyone has personal preference and different ways of remembering things. It's important to respect that*. (HCN student, SRP: 3)

Although the majority of the students in this study spent 10 – 20 minutes reading and taking notes, most of them did not share their experiences with us and those that did vaguely referred to the two functions of notes. Like many of their fellow students in the 20 – 30-minute timeframe, they offered teaching suggestions related to their personal preferences.

Time spent less than 10 minutes. 19 students spent less than 10 minutes on this reading and note-taking task and 7 of them offered us insight into their experiences. It was the non-note-taking students who voiced their opinions about the value of taking notes this time and not the other groups. None of the PN students contributed any comments.

Several students found the assignment difficult because they were asked not to take notes or they had to use the computer. They said that they had a hard time focusing and retaining information over the long term, felt that note-taking improves one's understanding, and struggled with the Cornell system's format on the computer.

> *Sometimes the text is boring. that* [sic] *makes it harder to stay focused on it*. (NN student, SRP: 3)
>
> *Having no notes can be easy, but the information learned can only be shorterm* [sic] (NN student, SRP: 2)
>
> *I think that note taking further enhances your understanding on the thing your reading* (NN student, SRP: 2)

> *Sometimes on the computer it is difficult to take notes because of the format*. (TCN student, SRP: 3)

The three note-taking students would most likely agree with this HCN student who liked taking notes by hand because it helped them limit interruptions,

> *I think that taking notes by hand can help you focus a lot because the interruptions are limited* (HCN student, SRP: 3)

And the other two students who provided us with comments, felt that a different system was better than the Cornell system and they did not need to take notes in order to understand the material.

> *Harvard note taking was a more efficient way of note taking* (TCN student, SRP: 4)
>
> *I honestly feel as if I can retain enough information without taking notes* (TCN student, SRP: 3)

Students who spent less than 10 minutes did not provide much insight into how they spent their time but since the majority of the students who did not take notes fit into this timeframe, and these students had the lowest mean score on the reading comprehension test, we believe that the non-note-takers did not spend a lot of time encoding the article's information. Perhaps they experienced more interruptions than the other students and simply stopped reading.

Assertion #2: Using the Cornell note-taking system can help eighth grade students alleviate the impact of interruptions upon their limited working memories

Miller et al. (1960) wrote, "working memory may go awry, especially when the execution of a task has been interrupted for some reason" (p. 69). Dabbish, Mark, & González (2011) tell us that self-interruptions lead to fragmented attention and that getting interrupted leads to more self-interruptions. When an eighth-grade student decides to interrupt themselves several times while reading and taking notes because they are responding to technological and non-technological interruptions (such as an Instagram notification or their dog barking), they are causing "infostress" (Klingberg, 2008, p. 106). Infostress is caused by an excess of incoming information into the brain that can impair working memory and long-term memory. Infostress can lead to students feeling that they do not have control over their thinking, or what they are learning. Basically, this entire study was based on these notions because we compared the effects

of taking notes with a computer and with paper in an environment, their homes, that may or may not lead to more interruptions than in school.

Based on the age of the students, we expected the students to tell us that they were interrupted more by technological sources than non-technological sources, but we were mistaken. In this section, we describe our mistake and provide evidence to support the idea that the Cornell note-taking system can help alleviate the impact of interruptions on the memory systems of middle school students.

Students experienced the same number of technological interruptions as non-technological interruptions. Forty-nine percent of the students responded to the question on the questionnaire that asked them if they were interrupted while reading and taking notes and if so, how. Fifty students said they were interrupted by technological and non-technological sources. Twenty-five students were interrupted by technology sources and 25 by non-technological sources. This was a surprising finding and an encouraging one because it told us that students were aware of the types of interruptions affecting them. Thirty-one percent of the TCN students were interrupted by technology followed by the HCN group (30%) the PN group (24%) and the NN group (13%). Thirty-nine percent of the NN group were interrupted by non-technological sources followed by students from the PN group (24%), the HCN group (17%) and the TCN group (15%).

As previously mentioned, technological interruptions only accounted for half of the reported interruptions. Students said that non-technological sources interrupted them and many of these sources have been interrupting students since students started doing homework. The list of sources included: family members, dinner, sleep, other homework assignments and plain old procrastination. As expected, the middle school students said they were interrupted by social media designed by engineers to interrupt them with audio and visual notifications. These notifications are initiated by others the students know who are connected to them through the Internet. We coded this group of distractions, Purposeful Interrupting Apps (PIA), and only coded social media apps the students listed on the questionnaire. This list included: Instagram, Skype, Text Messaging, Snapchat and WeChat and may have been engineered to interrupt just like Facebook was. We were not astonished to find that students were interrupted by social media, but we were alarmed to find out that they might want to be interrupted.

In an article written in The Telegraph Online by Matthew Field (2017), a former president of Facebook, Sean Parker, admitted that the Facebook engineers designed the software to constantly interrupt their users to keep them connected to Facebook. Field wrote,

> *Parker, who has made billions as an early shareholder in the social network, also criticised [sic] Facebook's effect on children. "It literally changes your relationship with society, with each other," he told newsite Axios. "It probably interferes with productivity in weird ways. God only knows what it's doing to our children's brains. The inventors, creators... understood this consciously. And we did it anyway," Parker said.*

Although none of the students listed Facebook as a social media tool that interrupted them, many of them generically listed social media on the questionnaire, so Facebook may or may not be part of the mix of tools. Based on our own experiences with the social media apps mentioned by the students, we wondered if the engineers of these apps programmed them in the same manner as Facebook. But even if they did, two authors believe that the students would be ok with how the apps were designed.

Torkel Klingberg (2008) claims that people are not "victims of ruthless technological progress" (p. 166); he believes that "many people seek out situations that demand concurrent performance or situations in which they are overwhelmed with information" (p. 167). In other words, many middle school students may in fact enjoy doing their homework while being interrupted by friends using social media. Nicholas Carr (2011) would agree with Klingberg because he states that interrupting tools cause our brains to want more of what the social media apps offers. If we accept Carr's and Klingberg's argument that people, in this case students, want to be interrupted, is this acceptable and should adults allow this to happen? And are these interruptions causing problems with learning? And if so, how can teachers help students reduce the impact of interruptions on the students' minds.

The Cornell note-taking system can help alleviate the impact of interruptions. Each of the note-taking groups produced a similar percentage of students reporting interruptions (PN: 48%, HCN: 47% and TCN: 46%) and the NN group (52%) was not too far ahead of them. Despite these similar percentages, there was not an equal percentage of students who felt prepared for the reading comprehension test or time spent on the reading and note-taking task. Students in the NN group had the lowest mean score (5.87), the largest percentage of students who felt the least prepared for the test (26%) and who spent less than 10 minutes on the reading

and note-taking task (43%). We believe that the act of note-taking with the Cornell system could have helped these non-note-taking eighth-grade students handle their interruptions because the two functions of note-taking, encoding and external storage, are supported by the system.

According to Piolat et al. (2005), note-taking integrates new information, if encoded properly, into long term memory. Note-taking slows down reading and enables the note-taker to encode the new material so that it becomes attached to existing schemas in the brain. As we have written about earlier, encoding requires students to select information from the text they are reading in order to paraphrase and summarize it into some organized structure. The Cornell note-taking system provides sections for each of these two behaviors and we believe can help lessen the impact of interruptions.

Obviously, the main way to reduce the impact of interruptions is to eliminate them. Using the Cornell note-taking system cannot accomplish this of course, but a teacher or parent armed with a small amount of information about how the brain processes information could make a difference. A thorough understanding of how the brain manages attention and new information is beyond the scope of this paper, but educators could start by telling their students how the two types of memory, working and long term, are addressed in the Cornell system.

Working memory enables a person to remember information for a very limited period of time. It controls attention, remembers instructions, keeps track of plans and solves complex problems (Klingberg, 2008). If reading and comprehending an article is thought of as a complex problem to solve, the Cornell note-taking format can help one's working memory because the note-taker can use the large section of the notes document to write down ideas, while reading, in order to lighten the cognitive load on one's working memory. This concept is especially important for students to understand because working memory controls attention, so when a student's attention is interrupted by a notification, the student's working memory has to decide what to attend to.

For example, if a student reads an article without taking notes and they get interrupted by a notification from a social media app, they have to stop reading, give their attention to the notification, decide to address or not address the notification, begin reading again, understand what they are now reading and remember what they just read. These cognitive processes may be too much for young students and as Carr has pointed out for us, "psychological research long ago proved what most of us know from experience: frequent interruptions scatter our thoughts,

weaken our memory, and make us tense and anxious" (p. 132). In other words, without a way to improve memory, such as taking notes while reading, students who are constantly interrupted may just feel too anxious about what they are doing and just stop. This may explain why so many students in the NN group (43%) spent less than 10 minutes reading and taking notes.

The Cornell note-taking system also provides a space for students to summarize, or encode new information, which in turn integrates this new information with existing cognitive structures in long-term memory. After notes have been recorded and summarized, students can use the external storage function to review their notes in many different ways. The note-taking system probably helped many students in this study overcome interruptions in order to understand the persuasion article and obtain a high score on the reading comprehension test, so we thought it was important to let 6 students, who did not report any interruptions explain how the system helped them. Here are their words,

> *i* [sic] *feel like the cornell* [sic] *notes really helped me understand the text better compared to regular note taking*. (TCN student, SRP: 5)
>
> *I really liked the digital Cornell strategy, it was one of my first times using it (I was an exec) and I think it worked quite well. It was efficient as it was done digitally, while still making me stop and look back at the notes taken to create questions, a summary, etc*. (TCN student, SRP: 5)
>
> *Cornell notes gives you multiple chances to review your notes, and thats* [sic] *a positive*. (TCN student, SRP: 4)
>
> *Cornell notes can be really helpful for reviewing notes several times*. (TCN student, SRP: 4)
>
> *Taking Cornell Digital Notes was very helpful because it allowed me to summarise* [sic] *my notes and re-read them to know what I wrote*. (TCN student, SRP: 4)
>
> *The summary portion of the Cornell Note Taking technique helped me reflect. It also gave me a clear overview of what I learned*. (HCN student, SRP: 5)

We would like to point out that all of these students had a self-perceived preparedness score for the comprehension test of "5" or "4". Since note-taking demands a lot of the central executive functioning of the brain (Piolat et al. 2005), or the part of the brain that determines what a person should pay attention to, these confident students may not have paid attention to the people trying to interrupt them because they were too busy writing notes and summaries. We

recognize that 6 students out of 101 is not a very large percentage, and so that is why we used the cautionary words "*can help* alleviate the impact of interruptions." Since the first author did a "notes check" with all of the note-taking students prior to them taking the reading comprehension test and their notes including encoding behaviors, we believe that many of the note-taking students felt the same way about the Cornell system, but just chose not to tell us about their experience.

Students in all four groups were interrupted by technological and non-technological sources. Due to the design of the Cornell note-taking system, students who use it properly may be able to help themselves manage inevitable interruptions at home.

Summary and Conclusions

After a group of eighth-grade students received instruction and practice using the Cornell note-taking system they were assigned to one of three note-taking groups or one non-note-taking group. Students were asked to read an article about persuasion and use their note-taking system to take notes at home. When they returned to school on the next day, they completed a 10-question multiple choice reading comprehension test and a questionnaire. Comprehension scores were analyzed with descriptive statistics and a box-and-whisker plot. Outliers were identified and a one-way ANOVA was conducted to determine significant differences in the mean scores. A Tukey HSD post-hoc analysis was performed to determine the differences between groups.

On the reading comprehension test, students who handwrote their notes using the Cornell note-taking system outperformed students who typed their notes using the Cornell system, students who used their own note-taking system and students who did not take notes. A one-way ANOVA found a significance in the group's means and a Tukey HSD found significant differences between each note-taking group and the non-note-taking group. Significant differences were not found between the note-taking groups. Two conclusions can be drawn from these results. First, students must take some form of notes to benefit from the encoding and external functions of note-taking. And secondly, the note-taking system a student uses while reading an article does not matter if the learning goal is only to take notes to pass a test. This conclusion is written with caution because this study only examined one article and several students thought that the article was not difficult to understand and notes were not necessary. The Cornell note-taking system may prove to be very important to students if the content of an article

was in a different subject area like science or math (we suggest this in the future research section) or the article was deemed to be more difficult.

In an effort to understand these results and the students' note-taking experience, data from the questionnaire was used. The students' self-reported feelings of preparedness, their time spent reading and taking notes, overall comments about their experience and their reporting of interruptions was analyzed using constant comparisons and questioning strategies (Corbin and Strauss, 2015). The students in the Cornell note-taking groups felt more prepared for the comprehension test and spent more time on the tasks than the personal and non-note-taking groups. Students who spent 20 – 30 minutes stated how they took notes using words that described the encoding and external storage functions of notes, whereas students from other timeframes opined about their experience and offered suggestions to the researchers. An equal number of technological and non-technological interruptions were reported among the groups, with the non-note-taking group reporting the most interruptions and they were mostly non-technological in nature.

Middle school teachers wishing to transform their note-taking instruction from paper to the computer should feel confident that their students will be able to make the adjustments. They should feel assured that their middle school students can handle using a traditional high school and college aged note-taking strategy like the Cornell system. The MS teachers should not fear giving their students reading and note-taking homework assignments at home. This study has demonstrated that the Cornell system can be used to alleviate the impact interruptions have on students' working memories.

Implications for Teaching and Learning

An overwhelming percentage (84%) of participating 8th grade students stated that they would like to take notes with their computer and in their own way. At least 50% of the students in the HCN and TCN groups, even after being taught a proven and effective note-taking system would still like to take notes in their own way. This observation, that Middle School students don't want supervision or direction in taking notes isn't too surprising. As this age group tends to be seeking more autonomy and resisting adult control of their lives. In a 1-1 teaching environment, a computer is a major component of their independent selves and reading is often an independent exercise, so it isn't surprising that students don't want to be told what to do. Yet

students do seem to be aware of their own limitations with regards to feeling prepared for a reading comprehension test and about recognizing interruptions that can occur during reading and note-taking. Many of them are aware of the benefits of using a system, but are reluctant to use one, perhaps viewing it as more work. This cognitive dissonance is a major obstacle to instruction, and "selling" the benefits of a note-taking system will be difficult.

We set out to learn more about the impact of technology on the modern middle school student, specifically how it impacted the age-old reading comprehension strategy of note-taking. As teachers continue enhance or transform traditional teaching methods and learning tasks, as per the SAMR model, they should consider using the digital version of the Cornell note-taking system. We have shown that typing notes on the computer with this system can lead to the encoding of information, high feelings of preparation.

Student learning behaviors are affected by things like socialization, ability level, personality and more. It appears that using computers while asking an 8th grader to read has a high likelihood of distraction for the student, but not more than traditional distracting sources like a younger sibling. The results of this study shed light on a few pedagogical practices teachers could utilize if they wanted to allow students to take notes via their computer. They are:

- Require the use of a guided system like Cornell Notes,
- Provide instruction, support and feedback on the note-taking process
- Provide opportunities for students to review notes in class,
- Allow students the option to handwrite their notes,
- Communicate with students why these protocols are being followed in order to get buy in.

Limitations and Future Research

This study examined the effects of enhancing & transforming the note-taking process with computers using the Cornell note-taking system with eight graders. Students in the note-taking groups handed in their notes to the first author prior to taking the reading comprehension test, but the students' notes were handed back to them and were unavailable for analysis. Future research might study the students' notes to determine the students' encoding abilities and to identify computer-based note-taking strategies, such as copying and pasting within the notes. A few students thought the persuasion article was easy to understand, despite being rated at a ninth-

grade reading level, and because of this, they did not feel the need to take notes. Future researchers might investigate the effects of a more difficult reading, perhaps in the science or math fields. And finally, future research might investigate the relationships between time spent reading and taking notes with students' perceived preparedness, their test scores and the quality of their notes using statistical procedures.

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