The Effect of Note Taking on Learning

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Nearly all college students take notes in class and surveys among college students indicate note taking is a common practice (Palmatier & Bennett, 1974). Few studies conducted on note taking in classroom-based settings have consistently found that note taking facilitates recall (Locke, 1977). However, most of the research performed on note taking predates laptops and embedded devices. Additionally, the use of laptops is a relevant controversial issue among teachers and students. The primary goal of our study is to analyze the effectiveness of the medium in which notes are taken (handwritten or electronic), and how it affects learning. Moreover, our study approaches learning from a classroom-based approach and not through another medium such as cognitive tutors or computational learning environments.

Literature Review

Most students believe note taking is helpful for learning (Davy & Dunkel, 1989). Note taking is comprised of several skills which include listening, processing information within a classroom setting, recording lecture material, and reviewing notes (Hughes & Suritsky, 1991). Recording lecture material and reviewing notes increases recall and has significant encoding benefits (Kiewra, 1985b, 1989). Moreover, the act of taking notes is linked to enhanced knowledge retention and understanding of classroom material (Mueller & Oppenheimer, 2014). Furthermore, Scardamalia and Bereiter (1986) suggest note taking forces recall of lecture material compared with merely hearing lecture material (Bui, Myerson, & Hale, 2013). Additionally, students who take notes perform better on lecture-based assessments than those who only listen (Kiewra, 1985b). Unfortunately, most research conducted on note taking does not consider an important comparison group consisting of participants who do not take notes.

Moreover, most research does not include application-based questions within their assessments. Our study aims to include both a no notes condition and application-based questions within the assessment.

Handwriting notes is generative because it includes listening to a lecture and selecting the important parts of every topic, consolidating and assimilating conceptual schemas from that information, and writing it down (Mueller & Oppenheimer, 2014). Processing information within a classroom setting is a two-step process in which a person must comprehend every lecture idea and relate that understanding with their existing knowledge (Hughes & Suritsky, 1991). Hand-writers have to be selective with their writing, and rephrase notions in their own words (Mueller & Oppenheimer, 2014). Therefore, this leads to enhanced processing for hand-writers (Mueller & Oppenheimer, 2014). More importantly, three experiments of the same study found that students who handwrote notes correctly answered more conceptual questions than students who took laptop notes (Mueller & Oppenheimer, 2014). It was also found students who handwrote notes and reviewed their notes afterwards performed significantly better than students who took laptop notes (Mueller & Oppenheimer, 2014). Unfortunately, this study does not consider a comparison group of students who do not record notes. Also, Mueller's and Oppenheimer's research does not assess students with application-based questions within the first two experiments of their study. Our study aims to explore the effect of the note taking medium on both conceptual and application-based questions. As a result, this would increase the ecological validity of our study.

Electronic note taking is non-generative because it involves listening to a lecture and not summarizing notions into one's own words (Mueller & Oppenheimer, 2014). More specifically,

the condition is non-generative because people type faster than they can handwrite and there is a tendency among students to transcribe lecture word for word (Kiewra, 1985a; Mueller & Oppenheimer, 2014). Consequently, this leads to trifling processing of classroom information, less encoding benefits, and poorer performance than students who handwrite notes (Kiewra, 1985a; Mueller & Oppenheimer, 2014). Within two experiments of a study, participants who took more notes correctly answered more factual and conceptual questions (Mueller & Oppenheimer, 2014). Mueller and Oppenheimer (2014) discuss that participants who took laptop notes performed worse on tests comprised of conceptual and factual questions. Moreover, Mueller and Oppenheimer (2014) find that students who handwrite notes retain more knowledge and can recall more than students who take laptop notes. Unfortunately, it is unclear why students who took more notes performed better in two of the three experiments within Mueller's and Oppenheimer's (2014) study. Our study aims to test these findings and include a comparison group to verify the effect of reviewing notes on assessment scores.

Current Study

Our study adds to the emerging literature of assessing if the medium of note taking affects learning. First, our experiment assesses whether taking handwritten notes is better for knowledge retention than taking notes on an electronic device. Secondly, our experiment assesses whether taking notes on an electronic device is better for knowledge retention than not taking any notes. Consequently, our study will add to the existing literature of increased recall in people who take notes note than people who do not take notes. Participants will be assessed on immediate recall through an assessment that will be administered after a lecture. The hypotheses of our experiment are as follows:

H1: People who take handwritten notes will learn more enabling them to correctly answer more questions when assessed compared to people who take electronic notes.

H2: People who take electronic notes will learn more enabling them to correctly answer more questions when assessed compared to people who do not take notes.

Method

Participants

The sample size was 25 Georgia Tech students enrolled in Psychology 2015: Research Methods. Additionally, the sample mainly consisted of College of Computing students. Those excluded from the study were any students with disabilities such as those who are blind or with an injury that affects note taking. Moreover, students caught cheating on the assessment would have been disqualified from the study. Thankfully, no one attempted to cheat.

This study utilized a non-probabilistic sampling technique, convenience sampling, taken from Psychology 2015 classrooms and participants were randomly assigned to three different groups. The participants were randomly assigned to one of three levels: handwriting notes on 8.5" x 11" college-ruled paper, taking notes electronically, or to not take notes at all. More specifically, 10 participants were randomly assigned to both no notes and handwritten notes conditions, and five participants were randomly assigned to taking notes electronically. The participants were not compensated for this study, but they were incentivized by class participation grades.

Design

The study's purpose was to explore the effect of note taking on learning. This study was an experiment because we randomly assigned participants to each level of the independent

variable and we established temporal precedence by manipulating the independent variable. Since the experiment applied random assignment, it had internal validity. Additionally, this study utilized a post-test only independent groups design. The researchers randomly assigned participants to one of three conditions; handwriting notes, taking notes electronically, or not taking notes at all. More specifically, the control group of this study was comprised of students who did not take notes.

The dependent variable for this study was a student's performance on the knowledge-based and application-based assessment. More specifically, the outcome variable was the number of correct responses of the 30 question assessment. Each question was worth one point and the maximum score possible was 30 points. We believe the multiple choice assessment accurately measured how much a student learned in the lecture.

Materials

The participants randomly assigned to handwriting notes received 8.5" x 11" college-ruled paper, pencils, and erasers. According to a previously administered survey on note taking, 10 out of 54 Georgia Tech students were in favor of taking notes electronically and all of those students used either a laptop or a tablet. Therefore, participants who were randomly assigned to taking notes electronically used their laptops or tablets to record information. All students were seated at desks and were handed consent documents and pencils. The instructor used a whiteboard, projector, laptop, and markers for their lecture. A researcher discussed a novel topic, Address Resolution Protocol (ARP) cache poisoning, to the class. This topic was determined through a survey involving several topics in which our sample identified their familiarity with each survey item through a Likert-Scale. None of the participants in the sample

were familiar with ARP cache poisoning. According to a survey we administered on note taking, 52 of 54 Georgia Tech students reported reviewing their notes. Therefore, participants were given two minutes to review their notes after the lecture. Lastly, all participants were given a sheet of 8.5" x 11" white copy paper with multiple choice questions, a pencil, and an eraser to complete the assessment.

Procedure

At the beginning of the experiment, participants walked into the room, were given a number which corresponded to an assigned number section, and were seated in their assigned section. In order to participate in the study, all participants needed to review and sign the necessary consent forms. Participants that signed the consent form sat through a 30 minute lecture on a novel topic, ARP cache poisoning. A combination of writing on the board, a verbal presentation, and using the overhead projector to show code snippets and demonstrate concepts were used to lecture to the participants.

Next, participants were given two minutes to review their notes. The participants reviewed their notes individually and without any collaboration with their peers. Moreover, participants were not allowed to share notes. If participants had shared notes or collaborated with their peers, then those involved would have been disqualified from the study. After the two minute review, participants were asked to put away their notes. Next, the participants were given a writing utensil, and a single sheet of 8.5" x 11" white copy paper for scratch paper. Lastly, all participants were given 17 minutes to complete a multiple choice assessment comprised of 30 questions. Some questions required multiple answers. After participants completed the

assessment, they handed it in to the nearest researcher. Subjects did not need to be debriefed about the study because this study did not deceive the participants.

Results

The experimental data were analyzed with IBM's statistical software package, SPSS. We used a between-subjects one-way analysis of variance with note taking as the categorical, independent variable and the number of correct responses as the quantitative, dependent variable. The conditions for the independent variable were no notes, handwritten notes, or electronic notes. The range for the dependent variable is the interval of positive natural numbers between 0 and 30 correct responses.

Since this study involved three independent groups, we wanted to determine whether there were any statistical differences between the means of these independent groups. We used an overall F statistic to determine if there were any differences between any of the groups. The main effect of note taking was statistically significant, $F(2, 22) = 3.93$, $p = .04$. Since there was an overall significant effect, post-hoc Tukey tests were conducted to determine where the differences occurred between those groups. There was a significant difference between the no notes ($M = 12.00$, $SD = 7.24$) and electronic notes conditions ($M = 20.40$, $SD = 3.29$), such that the electronic notes condition scored higher than the no notes condition, $p = .03$. There was no significant difference between the no notes and handwritten notes conditions, $p = .27$. Lastly, there was no significant difference between the handwritten notes and electronic notes conditions, $p = .39$.

Discussion

The post-hoc Tukey test results indicated that there was not a significant difference between handwritten notes and electronic notes conditions, which does not support our first hypothesis. Furthermore, there was a significant difference between the no notes and electronic notes conditions, which does support our second hypothesis. Therefore, the post-hoc Tukey tests support the hypothesis, H2, but the weight of evidence does not support the hypothesis, H1.

Our study does not confirm the suggestions of many researchers in which handwritten notes are more effective for learning than electronic notes (Mueller & Oppenheimer, 2014). More specifically, this study may support the findings of Mueller's and Oppenheimer's (2014) studies in which performance is dependent on the quantity of notes taken. However, our study confirms that note taking leads to better retention and performance than no notes (Kiewra, 1985b). It is evident that students who take and review their notes correctly answer more questions than those who do not take notes. Our study supports Kiewra's (1985) observation that note takers who review their notes achieve more than those who do not take notes. However, more time should be allocated to reviewing notes because reviewing notes is more powerful than the note taking behavior itself (Kiewra, 1985a; 1985b).

The simplicity of our experimental design is a strength of our study. More specifically, the manipulation of our variables were reasonable. Moreover, the students in our sample are a strength of our experimental design because they understood the experimental instructions and assessment questions without any difficulty.

On the other hand, this study has many methodological flaws. First, the sample obtained in this study was through a non-probabilistic sampling technique, convenience sampling. In turn,

the results of this study are not likely to represent the population of interest because our sample may have different opinions from those less willing to participate. Instead, a simple random sample such as a cluster sample or a stratified random sample would have significantly increased the external validity of this study. Moreover, our sample size is very small. While a large sample size does not necessarily increase the ecological validity of a study, it would verify the main effect(s) of this study.

This study also suffers from an instrumentation threat because the assessment questions are not categorized using a codebook. Instead of having only conceptual and application-based questions, factual and inference questions (i.e., questions facilitating far transfer) should also be included. In turn, mental processing differences between conditions may be detected. Additionally, this study suffers from a selection effect because participants in one condition could be systematically different from those in another. Matched groups should be implemented because it has the advantage of randomness and ensures groups are equal on subject knowledge. Moreover, researchers should randomly assign an equal number of participants to each condition.

The experimental design of this study tests for immediate recall, rather than recall over a period of time. The intent of this study was to study the effect of note taking in a classroom-based setting, but time constraints of this study did not make this possible. Instead, this study should be implemented as a longitudinal study because recall should be tested after several lectures or weeks. Furthermore, a longitudinal study would help detect differences in knowledge retention between conditions.

Our study design only conducts one experimental trial. Future studies should conduct multiple trials to help attribute differences in the outcome variable to a particular condition of the

independent variable. Lastly, the novel topic chosen is esoteric. Future studies should not lecture on an esoteric topic because it becomes very difficult to realize differences in the subjects' fundamental knowledge. Essentially, we could obtain a null result due to a floor effect of the dependent variable.

Overall, our study was useful because we gained insight on how an experiment of this nature should be conducted. Moreover, our study provides insight on the experimental design flaws encountered and how to combat them to improve the power of this study. In conclusion, note taking does have an effect on learning.

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