Examining Longhand vs. Laptop Debate: Evidence from a Replication

Completed Research

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Abstract

There is a considerable controversy regarding technology in the classroom, with some studies arguing the benefits of technology in the classroom and others suggesting that a technology free environment is superior. In an effort to address this controversy, Mueller and Oppenheimer (2014) conducted three different experiments to determine whether typing notes on a laptop or handwriting notes in a notebook impacted academic performance. This research replicated the first of these experiments in a classroom environment as opposed to a lab environment. The original study found that students who did not use laptops for note-taking in class performed better on conceptual application questions, which was not significantly confirmed in our study. However, our findings did support the original study when looking at the content analysis of student notes. Our updated findings suggest there is more work to do to understand the longhand versus laptop debate.

Keywords

Laptops, note-taking, technology in classroom, higher education, replication.

Introduction

There is considerable controversy regarding technology in the classroom. Some studies argue that technology can benefit the classroom in regards to structured activities (e.g., Kay and Lauricella 2011). Other studies suggest that a technology free environment is better for learning, with recognition that students are generally distracted by the use of technology in the classroom (e.g., Ragan et al. 2014). In fact, the term "cyber-slacking" has been coined to refer to the use of technology in the classroom for non-class related activities (Rana et al. 2016). It is important for faculty to understand the impact of technology in the classroom. Not only do faculty have to understand the role that laptops, tablets, and phones can play in the classroom; there are now Hands Free Always On (HFAO) technologies, like internet connected watches or rings, that can impact classroom learning outcomes as well (Suasnabar et al. 2015).

In relation to classroom note-taking, there has been controversial findings as well. For example, there is research that indicates students bring laptops to class for the use of note-taking (Houle et al. 2013). On the other hand, there is research that suggests laptops are a distraction when it comes to keeping notes (Benbunan-Fich and Truman 2009; Galluch et al. 2009). Likewise, a recent study from Mueller and Oppenheimer (2014) concluded that longhand note-taking is preferable, as students perform better on conceptual questions. The researchers also found that student learning was impaired due to a tendency to transcribe lectures when laptops were used for note-taking. This ultimately leads to shallower information processing, which is not as beneficial for learning as the reframing and understanding of information (Mueller and Oppenheimer 2014).

The goal of this research is to gain a better understanding of technology in the classroom and its role in note-taking. Specifically, the goal of this research is to replicate the previous study from Mueller and Oppenheimer (2014) to uncover whether or not the findings would be the same, thus helping to settle the controversy of technology in the classroom.

In the original research, Mueller and Oppenheimer (2014) conducted three different experiments to determine whether taking notes on a laptop or handwritten in a notebook impacted academic

performance. This research replicates the first of these experiments in a classroom environment as opposed to a lab environment in order to see if the findings are the same in a more practical and realistic setting. If this replication research confirms the findings of the original research, the current study would provide valuable "external third-party validation" (Dennis and Valacich 2015). If this replication research does not confirm the findings of the original study, this study would suggest that future research is necessary to solve the technology in the classroom controversy.

This paper is organized as follows: The next section presents the method for this research, which replicates what was done in the original study (Mueller and Oppenheimer 2014). The following section presents results of the replication study and contrasts them with the original study. This research concludes with a discussion, as well as future opportunities for researchers interested in understanding the use of technology for note-taking.

Research Methodology

Mueller and Oppenheimer (2014) conducted three different experiments to determine whether taking notes on a laptop or handwritten using longhand in a notebook impacted academic performance. The method of our research replicated the first of these three experiments in a different context.

The participants from this study included 58 undergraduate (35 male and 23 female) students at a university in the Midwest. For this study, students in a classroom setting were required to watch a TED Talk on how algorithms shape the world[1] while taking notes. The topic of the video lecture was stimulating, but not common knowledge. As in the original study, students were instructed to use their normal classroom note-taking strategy. However, the participants were split into two groups/classrooms instead of working in a lab two at a time as was done in the original study. The first group was asked to take notes using their laptops and the second group was asked to take notes via paper. The two groups of students in this study were comprised of two different sections of the same Information Systems (IS) course. All of the students in a particular section were asked to take notes via the same medium regardless of their preferred note taking method. Specifically, one section of the class was asked to take notes with their laptops and the other section of the course was asked to take notes via paper. It should be noted that student participation was voluntary, however students were motivated by extra course credit based on their comprehension of the TED Talk determined by performance on a quiz following the video.

After watching the video, students participated in regular classroom activities (i.e., lecture, notes, and in class activities) related to the regular content of the course (i.e., IS). The topic of the video was not discussed concluding the viewing. Approximately 30 minutes after the watching the video, students took a closed-note quiz based on the video with both factual recall and conceptual application questions (see Appendix A). Both the selected TED Talk and the quiz questions were used in the original study. The difference from the original study and the replication study is that the students were in a classroom setting as opposed to completing this exercise two at a time in a lab setting. The goal with this change in context was to be more reflective of note-taking in a classroom setting. Additionally, participants in this study were motivated to perform well on the quiz in order to earn extra credit points towards a quiz grade. Students could earn a maximum of 15 extra credit points on this quiz which could be applied towards a regular course quiz grade.

All quizzes were scored by the first author using the same grading scale as the original study. Additionally, the actual notes (both typed and handwritten) were collected and reviewed for word counts and content analysis. In order to compare the notes for content analysis, the handwritten notes from this study were transformed into typed notes by a research assistant. This process was similar to the original study. Any figures or illustrations from the longhand notes were noted in the typed documents but not drawn/included. The following section presents the results from this study in comparison with the original study.

[1] https://www.ted.com/talks/kevin_slavin_how_algorithms_shape_our_world

Replication Results

This section presents the quantitative and qualitative results from our study and contrasts the findings with the original study.

Quantitative Results

The quantitative data analysis for this study followed the same procedure as the original study (Mueller and Oppenheimer 2014). Data analysis reviewed the impact of note-taking medium on factual recall questions and conceptual application questions. However, the original study varied both note-taking medium (laptop vs. longhand) and the video and quiz type. In our study, we used the same video and quiz for all participants so there would be no variance in quiz difficulty. Additionally, we conducted an analysis of the student's actual note content as was done in the original study.

An independent-samples t-test was conducted to compare the factual recall question scores for students who took notes with laptops compared to students who took notes with notebooks. There was no significant difference in scores for laptop students (M=4.83, SD=1.34) and longhand students (M=4.57, SD=1.45), t(56)=.714, p=.49. The magnitude of the differences in the means was very small (eta squared=.009). This finding was consistent with the original study, which found that participants performed equally well for factual recall questions.

A second independent-samples t-test was then conducted to compare the conceptual application question scores for students who took notes with laptops compared to students who took notes with notebooks. Again, there was no significant difference in scores for laptop students (M=1.53, SD=1.28) and longhand students (M=2.00, SD=1.44), t(56)=-1.307, p=.20. The magnitude of the differences in the means did show a moderate effect (eta squared=.030). Statistically speaking, this finding was not consistent with the original study, which found that laptop participants performed *significantly* worse on conceptual application questions. However, it should be noted that the mean scores on conceptual application questions for longhand students were slightly higher than the scores for laptop students suggesting that longhand would be preferred over laptop notes, which is consistent with the original study.

Along with the review of factual recall questions and conceptual application question scores, we also conducted a content analysis of the student notes. In relation to the student note-taking content analysis, our findings were in line with the earlier study. Specifically, we found that participants who took longhand notes wrote significantly fewer words than those who typed their notes (longhand: M=76.5, SD=57.5; laptop: 186.2, SD=93.1), t(44.93)=5.31, p<.001. Figure 1 shows the difference in means from the current study in comparison with the original study. Both the original study and current study found that students who took notes on a laptop took more notes than students who were using longhand. However, in the current study, students took less notes overall than in the original study. We suspect that this finding is due to students working in a classroom environment instead of in a lab setting. In the original study, participants were recruited through a subject pool and studied two at a time in a lab setting. Perhaps the participants in the original study took more notes overall in an effort to be a valuable research subject. In this study, even though students read through and signed an IRB informed consent form and knew they were a part of a research study, they were still in their regular classroom environment. It is likely that the students in this research study participated in the experience as though they were regularly taking notes for class. This could explain the lower overall word count than in the original study. We suspect that this more realistic environment also resulted in a more realistic capturing of the student note taking process and results.

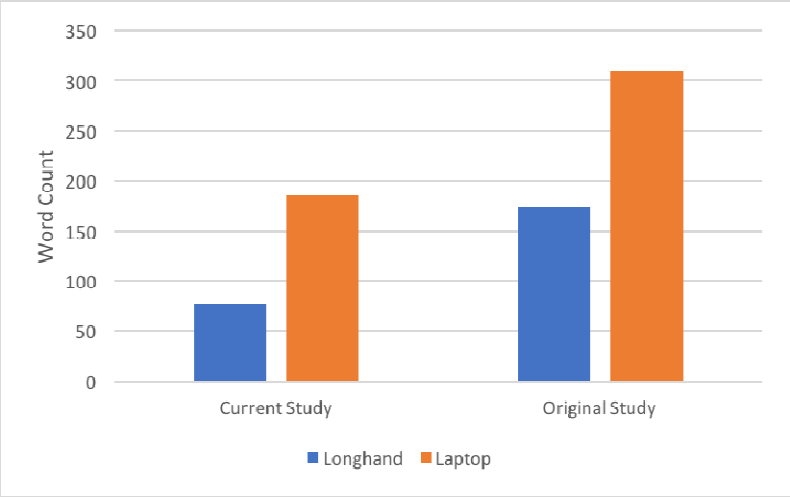

Figure 1. Average Word Count of Student Notes

Further content analysis looked at the verbatim overlap of notes taken in comparison with the actual TED Talk lecture transcript. Specifically, we used a simple n-gram program[2] in order to measure textual overlap between the student notes and the actual lecture transcript. For this step, we compared each three-word chunk of text in the notes with each three-word chunk of text in the TED Talk lecture transcript to find a percentage match for each participant. This step was similar to the original study. Our findings in this study were again similar to the original research. We found laptop notes had an average of 8.6% (SD=.8%) verbatim overlap with the lecture and longhand notes had an average of 6.5% (3.1%) overlap with the lecture, $t(30.67)=3.58$, $p=.001$. Figure 2 shows the comparison of the means from the current and original studies. Our finding here suggests that students who are taking notes with their laptop are doing more copying of what is being said during a lecture than students who are using handwriting in a notebook and have to be more selective about the notes they are taking. Similar to the word count comparison, the participants in this study had a lower percentage of overlap across both groups than in the original study. While some of this finding is likely associated with the word count differences (i.e., more words would mean more overlap), it may also be due to the change in context.

[2] http://lextutor.ca/n_gram/

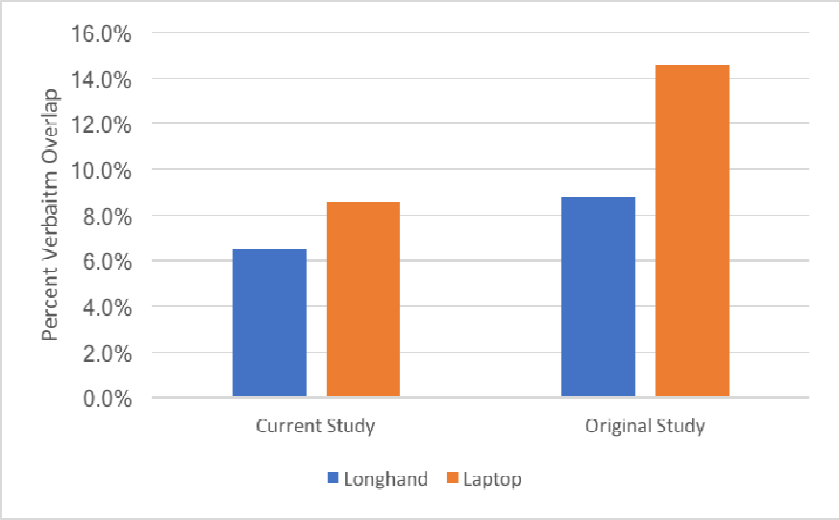

Figure 2. Percentage of Verbatim Overlap Between Student Notes and Lecture Transcript

Finally, this study found that participants who took more notes performed better with β = 0.004, p = .025, R2 = .10 for conceptual application questions and β = 0.002, p = .011, R2 = .11 for factual recall questions. This result is consistent with the original study. Verbatim text overlap, however, was not a significant predictor for the performance on both types of questions, which is inconsistent with the original study. Following Mueller and Oppenheimer (2014), we tested a model using word count and verbatim overlap (three grams) as mediators of the relationship between note-taking medium and performance using Preacher and Hayes' (2004) bootstrapping procedure with 1000 replications.

Mediator variables (MV) are variables that sit between independent variable (IV) and dependent variable (DV) and mediate the e□ect of the IV on the DV. A model with two mediators is shown in Figure 3.

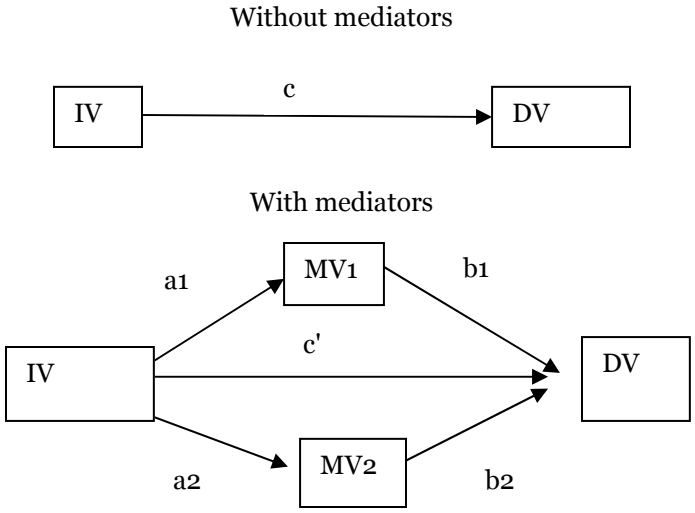

Figure 3. A Model with Two Mediators

In Figure 3, a represents the regression coe□cient for the IV when the MV is regressed on the IV while b is the coe□cient for the MV when the DV is regressed on MV and IV. The symbol c' represents the direct e□ect of the IV on the DV. In this work, we wanted to determine the indirect e□ect of the IV on the DV through the MV (a1b1 and a2b2). In our model, IV is the note-taking medium and DV is student's performance. The two mediator variables are word count and verbatim overlap.

Our findings suggest the indirect effect is significant if its 95% confidence intervals do not include zero. In the full model, the direct effect of note-taking medium is a significant predictor for conceptual application

question performance, $\beta = 0.62$, $p = .05$ but not for the performance on factual recall questions; the indirect effect of longhand notetaking on performance through verbatim overlap was not significant while the indirect effect of longhand notetaking through word count was significant. Longhand note-taking negatively predicted word count, and word count positively predicted performance on both conceptual application and factual recall questions, with indirect effect = −0.54, 95% confidence interval (CI) = [−1.09, −0.16] for factual recall questions performance and indirect effect = −0.48, 95% confidence interval (CI) = [−1.04, −0.05] for conceptual application questions performance. The original study found that both indirect effects were significant while we found that only the indirect effect though word count was significant.

Essentially, our findings suggest laptops may help academic performance as they can be used to help students take *more* notes which leads to better performance. This indirect effect through word count is consistent with the findings by Mueller and Oppenheimer (2014) but the indirect effect through verbatim is not consistent with the original findings as the verbatim overlap with the lecture has negative but *insignificant* impact on performance. However, we also found that students who take longhand notes do perform slightly better (though not significant) on conceptual application questions.

Qualitative Results

Along with the quantitative results from this study, qualitative feedback was gathered from the participants. This section explores some of these findings.

When asked about note-taking preferences, 26 of the participants selected laptop as their preference for notetaking. Most of the students who chose laptop as their preference attributed their selection to speed. Comfort was also mentioned by some students. For example, one student wrote: "*I can take down notes faster, writing causes finger pain.*" Others mentioned access, convenience, search-ability, and even page-design as reasons for preferring laptops.

On the other hand, 27 of the participants selected notebook as their preference for notetaking. Most of the students, who chose notebooks as their preference, attributed their selection to better recall/memory. For example, one student stated: "*I can remember what I write, not what I type.*" Many students also mentioned that notebooks were less "*distracting*" while in class. For example, one student commented that a "*laptop is too distracting, which is why my GPA is bad now.*" Other students mentioned the ability to "*design*" their handwritten notes easier or copy math formulas easier. One student even mentioned that handwritten notes were more reliable, stating, "*My laptop breaks all the time. I like hard copy.*"

Overall, the participants were evenly split on their preference of laptops or longhand for their notetaking. A number of comments suggested that students believe handwritten notes help most with memory. For example, one student commented, "*I have heard that handwriting notes helps with memory retention.*" Other comments suggested that the use of technology in the classroom is faculty driven. For example, one student stated, "*If we need laptops for class I use that to take notes. If I don't need a laptop then I use a notebook.*" Another stated: "*professor doesn't allow laptops=>become habit.*" These attributions to research support and faculty policies present some interesting ideas for future research, which are presented in the following section.

Discussion and Conclusion

The goal of this study was to follow up earlier work which provided initial experimental evidence that laptops were not beneficial for use in the classroom, specifically in relation to note-taking. This study replicated an experiment designed by Mueller and Oppenheimer (2014) where students were shown a lecture and either took notes via a laptop or using longhand in a notebook. This study was different from the original study in that the experiment took place in a classroom setting as opposed to a two-person lab environment. The original study found that students who did not use laptops for note-taking in class performed better on conceptual application questions, which was not significantly confirmed in our study. However, our findings did support the original study when looking at the content analysis of student notes. Both word count and verbatim overlap of lecture content were significantly higher for students who were taking notes in their laptops than using longhand. Our results did show that students who take more

notes performed better. The original study found that both indirect effects were significant while we found that only the indirect effect though word count was significant.

In conclusion, our findings suggest laptops may help academic performance as they can help students take *more* notes which leads to better performance. This indirect effect through word count is consistent with the findings by Mueller and Oppenheimer (2014) but the indirect effect through verbatim is not consistent with the original findings as the verbatim overlap with the lecture has negative but *insignificant* impact on performance. However, we also found that students who take longhand notes do perform slightly better (though not significant) on conceptual application questions. The fact that our findings do not completely confirm the findings from the original study, suggests that future research is necessary to solve the technology in the classroom controversy. Specifically, we would like to increase our sample size to see the impact.

Interestingly, the qualitative findings from our study seemed to suggest that the use of technology in the classroom is faculty driven. In fact, multiple students mentioned they have some faculty members who do not allow the use of laptops in the classroom. This adaption of the students' note-taking habits to the cues of the professor is a potentially interesting avenue for future study. Faculty may try using published research (e.g., Mueller and Oppenheimer 2014; Ragan et al. 2014; Rana et al. 2016) to inform students of their classroom policies regarding technology in the classroom. However, what is the impact if the classroom policy differences from student preference? Furthermore, future research may need to consider discipline differences regarding technology in the classroom. Perhaps it is the case that different disciplines or course subjects have an easier time removing technology from the classroom (e.g., math, economics, accounting, English). However, some courses require the use of technology due to the subject at hand (e.g., information systems, computer science).

Faculty who are interested in the debate over the use of technology in the classroom might try removing the use of technology in the classroom. If technology is required in the classroom due to the subject at hand but a faculty member is concerned about the distraction of laptops or other technology in the classroom, there could be other solutions. For example, previous research has presented the use of more active learning exercises in the classroom as a possible solution (Griffin 2014). Future research might also consider the use of technology intermittently during class. For example, it may be the case that a faculty member only involves technology at certain points during the class and not the entire class period. However, this may still result in challenges. While some technology can be easily removed from the classroom (e.g., laptops, tablets, phones) there are emerging technology innovations like HFAO technologies that are making this more difficult. What this study concludes is that further research is certainly needed to help solve the debate of technology use and value in the classroom related to both current and emerging technologies.

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Appendix A: Quiz Questions

Factual recall and conceptual application questions for TED Talk lecture (Mueller and Oppenheimer 2014)

Kevin Slavin – How Algorithms Shape Our World:
https://www.ted.com/talks/kevin_slavin_how_algorithms_shape_our_world

1. (conceptual – 2pts) How are algorithms useful for successful stock trading?
2. (factual – 1pt) What percentage of the trading activity on the U.S. stock market is done by algorithms?
3. (conceptual – 2pts) What are two problems that have resulted from algorithms being in control of important functions?
4. (factual – 1pt) What is the name of the algorithm that determines 60% of the movies rented through Netflix?
5. (conceptual – 2pts) How does the altered picture of the mountain range at the beginning of the talk connect with the speaker's main point?
6. (factual – 2pts) Between what two cities is the trench for fiber-optic cable to increase signal speed being built?
7. (factual – 1pt) Which of these is not the name of an algorithm the speaker mentioned in the talk?
    a. The Boston Shuffler
    b. The Carnival
    c. The Knife
    d. The Sniper
8. (factual – 1pt) What do Epogogix's algorithms claim to be able to do?
9. (factual – 1pt) What is the Boston company that finds and catalogs stock-trading algorithms called?
10. (factual – 2pts) In New York City, where is the Internet distributed from?

Demographic questions based on Mueller and Oppenheimer (2014)

1. How much knowledge related to the topic of the talk did you have before today?
    a. 1=None at all; 5 = Expert Knowledge
2. Please briefly describe your prior experience with/knowledge of the topic, if any.
3. What year will you graduate?
4. What is your GPA?
5. What is your major (if you have decided on one)?
6. What was your ACT score?
7. Do you normally take notes in class on your laptop or in a notebook? Why?
8. In general, do you think it is better for learning purposes to take notes on a laptop or in a notebook?
    a. 1=Laptop significantly better; 7 = Notebook significantly better
9. Does your choice to take notes on a laptop or in a notebook differ depending on whether it is a humanities, science, or math course?
10. How long do you normally spend reviewing notes when studying for a test?
11. Do you have any other thoughts regarding note-taking on a laptop vs. in a notebook?