Make a Note of It: Comparison in Longhand, Keyboard, and Stylus Note-Taking Techniques

Madelynn D. Shell, Maranda Strouth, & Alexandria M. Reynolds

Department of Psychology

The University of Virginia's College at Wise

Abstract

This study investigated the influence of longhand (paper and pen), keyboard, and stylus note-taking on academic performance in college classes. Students attended mini-lectures and took notes using longhand, keyboard, or stylus. Students took quizzes after each mini-lecture and reported their engagement. Final course grades were recorded. Note-taking did not directly affect recall, but students performed better using their preferred note-taking method. Stylus and longhand note-taking conferred advantages in course grades and were associated with higher perceived recall and engagement. Although there may be advantages to longhand and stylus note-taking, it is important to allow flexibility for student note-taking preferences.

Keywords: Note-taking, longhand, stylus, keyboard, Introduction to Psychology

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Note-taking is essential in college courses because it improves content memory and is an important tool for learning (Bohay et al., 2011). Longhand note-taking, using pen and paper to write by hand, is commonly used in college lectures, and some evidence has suggested it provides academic benefits (e.g., Morehead et al., 2019; Mueller & Oppenheimer, 2014). However, some students prefer technology-assisted note-taking tools, such as a keyboard, a stylus, and a touchscreen tablet. Stylus use mimics longhand processes, as note-takers use more complex motor movements, thus it may create similar benefits to longhand (Smoker et al., 2009), but it also produces digital files. As many campuses take on costly technology initiatives in hopes of improving students' academic outcomes, it is important to investigate how these technologies can contribute to success within the classroom.

Note-taking and Academic Performance

Longhand versus Keyboard

It is well-established that note-taking is important for remembering information and improving performance (Bohay et al., 2011; Jansen et al., 2017; Rahim & Meon, 2013). However, previous work demonstrates that different note-taking methods may have unique impacts on academic performance. Within the classroom, studies have shown general laptop bans increase

academic performance and exam scores (Carter et al., 2017; Patterson & Patterson, 2017). Although these studies do not specifically assess note-taking, one can assume that students without technology are taking longhand notes. In addition, students who either chose (Aguilar-Roca et al., 2012) or were assigned (Artz et al., 2020) to take notes using longhand performed better on class tests. More controlled lab studies have also confirmed the benefits of longhand versus keyboard note-taking on test performance and memory (Morehead et al., 2019; Mueller & Oppenheimer, 2014; Smoker et al., 2009), particularly if students are given time to review their notes (Luo et al., 2018). However, these effect sizes are often quite small.

Conversely, other studies have found benefits to keyboard compared to longhand. For example, although students in laptop-banned classes self-reported more improved knowledge, paper and exam grades demonstrated better performance in classes that allowed technology (Elliott-Dorans, 2018). In the lab, students did better on a test of memory after taking notes using keyboard versus longhand (Fiorella & Mayer, 2017). Students typing on a keyboard tend to include more words and more complexity (Luo et al., 2018; Morehead et al., 2019; Van Der Steen, 2017), which may improve scores. However, there may be shallower processing of information because of the tendency to transcribe information verbatim (Mueller & Oppenheimer, 2014). Thus, the keyboard provides the advantage

of more extensive, faster note-taking, although it may promote shallow processing.

Although numerous studies have investigated the impact of longhand and keyboard note-taking on academic performance, findings are still quite unclear. While some studies have failed to find differences in performance in all or some contexts (e.g., Bohay et al.; 2011; Carstens et al., 2015; Carter et al., 2017; Luo et al., 2018), there seems to be a slight advantage to longhand notes over keyboard. Technology itself may serve as a significant distraction in the classroom if the in-class internet and computer usage are non-academic. This may, in turn, have negative impacts on performance (Ragan et al., 2014; Ravizza et al., 2016). However, technology-assisted note-taking may not always be detrimental, and could, in fact, be advantageous depending on instructor support and the structure of technology use.

Stylus

In contrast to longhand and keyboard note-taking, relatively little research has been done on the effectiveness of a stylus for note-taking. A stylus is a digital pen that can be used on a touchscreen device to take handwritten notes. Notes created with a stylus can be saved, organized, converted to text, and edited (Pfeuffer et al., 2017). Because stylus and longhand writing processes are physically similar and produce notes similar in word count, complexity, flexibility, and spatial strategies (Morehead et al., 2019; van Wyk &

van Ryneveld, 2018; Wollscheid et al., 2016), one might expect similar benefits to memory and performance. Although Morehead et al. (2019) found no difference in performance between stylus, keyboard, or longhand, Osugi and colleagues (2019) found that stylus use may improve learning compared to longhand. Thus, because the stylus combines the advantages of longhand and technology-assisted note-taking, it could be an important tool that needs further investigation.

Class Engagement

Some note-taking methods may promote engagement during classes, in addition to academic performance. For example, more rapid note-taking on a keyboard may encourage classroom participation (Carstens et al., 2015). However, the deeper processing of information associated with longhand note-taking may result in greater cognitive engagement with the material (Mueller & Oppenheimer, 2014; Smoker et al., 2009). Similar effects may occur with stylus. As a result, students using stylus or longhand may be more able to readily answer questions and engage during class. Consistent with this, students in technology-banned classes reported more enthusiasm and interest in the class topic (although technology-optional classes had better attendance; Elliott-Dorans, 2018). Conversely, both keyboard and stylus note-taking provide the temptation for off-task behavior, which may limit engagement (e.g., Ragan et al., 2014; Ravizza et al., 2016), although some

evidence suggests this off-topic behavior does not negatively impact students' performance (Aguilar-Roca et al., 2012). Because class engagement is intertwined with deeper cognitive processing, understanding the engagement implications for various note-taking strategies could promote academic success.

Present Study

The inconsistency in previous findings suggests that the effectiveness of note-taking strategies may vary based on the specific conditions of use. Many previous studies of the classroom have looked at technology bans rather than specific note-taking modalities. Moreover, many of these studies simply provided students with the option to use technology (and those who chose to, brought their own devices). Thus, it is important to explore these effects when students have uniform access to the same technology. In addition, many of these studies aimed to answer questions about which methods work better for students in general. It is important to also consider the possibility that there may be individual differences in the effectiveness of and preference for various note-taking strategies.

Thus, this study compared three note-taking methods in college-level Introduction to Psychology courses. Students attended mini-lectures on three different topics and took notes using either longhand, keyboard, or stylus, and then took a short recall quiz. Students all used the same technology (Apple iPad, Apple Pencil,

and Smart Keyboard). After the final mini-lecture, students reported their general note-taking habits, and final course grades were collected. It was hypothesized that longhand note-taking would have greater benefits for performance within the activity and in the course compared to keyboard note-taking. Because stylus-use mimics components of longhand, stylus note-taking was expected to have similar performance benefits. In addition to these overall patterns, it was expected that students would demonstrate better recall performance when using their preferred note-taking methods. Finally, it was expected that longhand and stylus note-taking could lead to more student engagement compared to keyboard.

Method

Participants

Participants included undergraduate students 18 or older in three sections of Introduction to Psychology at a small public liberal arts institution. The study protocol was approved by the school's Institutional Review Board. As a result of a technology initiative, all students were provided an iPad, a Smart Keyboard, and an Apple Pencil, which they were directed to bring to class. All students participated in the activities as part of course lessons and were given a choice to opt-out, in which case their data was discarded. A total of 97 out of 118 potential students (82%) consented to have their data used for this study. Of those, 75 (77%) were present for all three mini-lectures, 21 (22%) were present for two of the three

lectures, and 1 (1%) was present for only one mini-lecture. Participants included 59 (61%) women and 38 (39%) men.

Participants ranged in college class, with 30 (31%) being first-year students, 34 (35%) being sophomores, 28 (29%) being juniors, and 5 (5%) being seniors. A total of 80 participants (83%) were European American, 9 (9%) were African American, 3 (3%) were Asian/Pacific Islander, 1 (1%) was Hispanic, and 3 (3%) identified as "other."

Procedure

Three mini-lectures were developed for this study. These lectures were more in-depth perspectives on topics that are covered briefly in the course: social comparison, autism, and attention-deficit/hyperactivity disorder (ADHD). For each topic, a 7-8 slide PowerPoint presentation was presented in class (approximately 10 minutes). Two instructors taught the courses (each taught their own class), and both used the same notes, PowerPoint slides, and other materials. Each mini-lecture was given in a different class period, over two weeks.

During the mini-lecture, participants were asked to take notes using either paper and pen (longhand condition), QWERTY Smart Keyboard and iPad (keyboard condition), or Apple Pencil and iPad (stylus condition). Immediately after the mini-lecture, students were given a quiz to assess recall. Students did not get feedback on their quiz scores or the correct responses. All sections received the topics

in the same order (social comparison, autism, then ADHD). Each class was randomly assigned to start with one of the note-taking conditions; then, all rotated through longhand, keyboard, and stylus. After the final mini-lecture and quiz, participants completed an additional survey.

Materials

In-class Recall Assessment

After each of three mini-lectures, students answered five multiple-choice questions that assessed recall of lecture content; recall was scored as number of correct responses out of five. There were no significant differences in recall scores between the two instructors.

Technology Perspectives Survey

After the final mini-lecture, students completed a survey about technology use. Students were asked, "what strategy do you think helped you remember the material the most?" and "what strategy do you think kept you the most engaged with the class and material?" in reference to the mini-lectures. Response options were paper and pen/pencil, keyboard, or Apple Pencil. Students were also asked, "what method do you normally use for note-taking?" and checked all strategies that applied.

Course Grade

The final grades in Introduction to Psychology were collected at the end of the semester, and grades were on a scale of 0 to 100.

Results

Academic Performance

Recall Performance

A 3 (note-taking strategy: longhand, keyboard, stylus) x 3 (lecture topic: social comparison, autism, ADHD) independent samples analysis of variance (ANOVA) was used to identify differences in correct responses to the recall quizzes based on note-taking strategy and topic. There were no significant effects for either note-taking strategy, $F(2, 268) = 1.294$, $p = .276$, partial eta squared = .010; topic, $F(2, 268) = 2.365$, $p = .096$, partial eta squared = .018; or a Strategy x Topic interaction, $F(2, 268) = 1.057$, $p = .378$, partial eta squared = .016. Thus, contrary to hypotheses, there were no overall recall differences for the note-taking strategies immediately after the mini-lecture. Means for each condition ranged from 4.11 to 4.67 out of 5 ($SD = 0.59–1.26$, Table 1).

In addition, to test whether students performed better on the quizzes in their typical note-taking strategies, we tested whether there was a difference in recall performance in the strategies that students preferred (i.e., used regularly in their classes) versus those they did not. These analyses were separated by lecture topic. For social comparison, there was no significant effect, $t(86) = -0.57$, $p = .568$, although students did score higher in their preferred method ($M = 4.50$, $SD = 0.76$) versus non-preferred ($M = 4.41$, $SD = 0.73$), Cohen's $d = .12$. For autism, students scored significantly better in

their preferred method (M = 4.73, SD = 0.45) compared to their non-preferred method (M = 4.29, SD = 0.89), $t(84) = -3.01$, $p = .003$, Cohen's $d = .45$ (a moderate effect). For ADHD, there was no significant effect, but there was again a trend for students to do better in their preferred method, with a moderate effect size (preferred M = 4.39, SD = 0.92, non-preferred M = 4.08, SD = 1.07), $t(92) = -1.481$, $p = .142$, Cohen's $d = .31$. Thus, although there were no overall effects of strategy, students had better recall when they were asked to use strategies that they regularly used on their own.

Table 1
Descriptive Statistics

	M	*SD*
Recall quiz topic		
Social comparison	4.45	0.74
Autism	4.55	0.70
ADHD	4.09	1.18
	n (yes)	%
Typical note-taking strategy		
Longhand	38	39%
Keyboard	54	56%
Stylus	58	60%

Note. Students could select multiple typical note-taking strategies. Recall quiz topic M and SD refer to the mean number correct out of five possible points. ADHD = Attention Deficit/Hyperactivity Disorder.

Perceived Recall

Chi-square tests were used to assess whether any strategy was perceived as more or less likely than chance to help recall in the mini-lecture. Despite the lack of general effect of note-taking on the

recall tests, there was a significant difference in strategies students perceived as helping them recall the mini-lecture material, $\chi^2(2) = 7.75$, $p = .021$ (Table 2). Pair-wise Chi-square tests were run post hoc to identify strategies that were significantly different. Consistent with expectations, there were no differences in perceived recall between longhand and stylus. In contrast, more students perceived greater recall with stylus compared to keyboard, $\chi^2(1) = 7.81$, $p = .005$, consistent with expectations. Marginally more students reported better recall with longhand versus keyboard, $\chi^2(1) = 3.63$, $p = .057$.

Table 2

Chi Square Comparisons of Student Perceptions

	Longhand		Keyboard		Stylus			
	n	%	*n*	%	*n*	%	χ^2	*p*
Perceived recall	34	35%	20	21%*	42	44%	7.75	.02
Perceived engagement	37	38%	22	23%*	38	39%	4.97	.08

Note. All responses relate specifically to the mini-lecture demonstration. Asterisk (*) indicates that a group was significantly different from the others ($p < .10$) based on pair-wise Chi square tests.

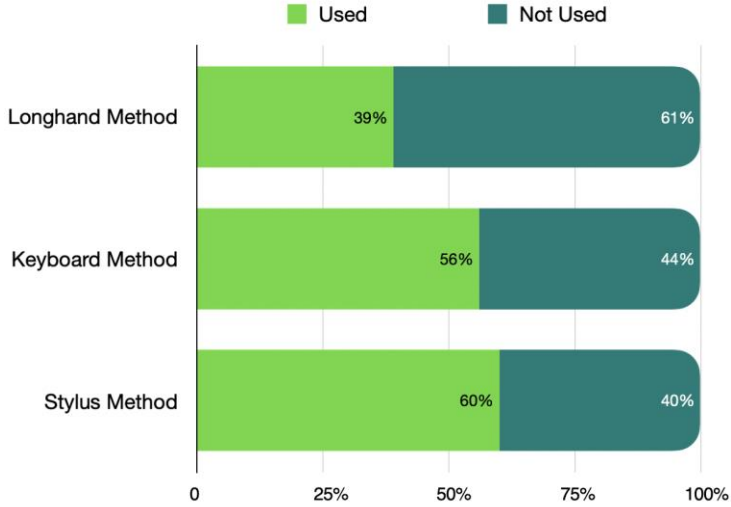
Course Grades

To assess the impacts of note-taking on semester-long course performance, associations between typical note-taking strategies and final course grades were examined. Students selected any note-taking strategies they typically used (not specific to the course, Figure 1). A total of 38 (39%) of students reported using vs. not using longhand, 54 (56%) reported using the keyboard, and 58 (60%) reported using the stylus. Next, the frequency of different combinations of methods was explored. The most common style was stylus alone (22%) or keyboard alone (21%), followed by a combination of keyboard and stylus (17%) or all three (13%). A total of 87% of students reported using some form of technology-assisted note-taking (alone in or in combination with longhand) on a regular basis. Independent samples *t*-tests were used to identify differences in final course grade for students who did versus did not use each strategy (either alone or in combination with other strategies, Figure 2). Consistent with expectations, students who reported regularly using the stylus ($M = 91.68$, $SD = 10.07$) had significantly higher course grades compared to those who did not use the stylus ($M = 86.84$, $SD = 13.00$), $t(95) = -2.06$, $p = .042$, Cohen's $d = .42$. Likewise, students who reported regularly using longhand ($M = 93.41$, $SD = 8.27$) earned higher grades than those who did not ($M = 87.73$, $SD = 21.71$), $t(95) = -2.60$, $p = .011$, Cohen's $d = .57$. There were no significant differences in course grades between students who did

(M = 89.41, SD = 11.63) versus did not (M = 90.15, SD = 11.44) use the keyboard, $t(95)$ = -0.31, p = .755, Cohen's d = .06.

Figure 1

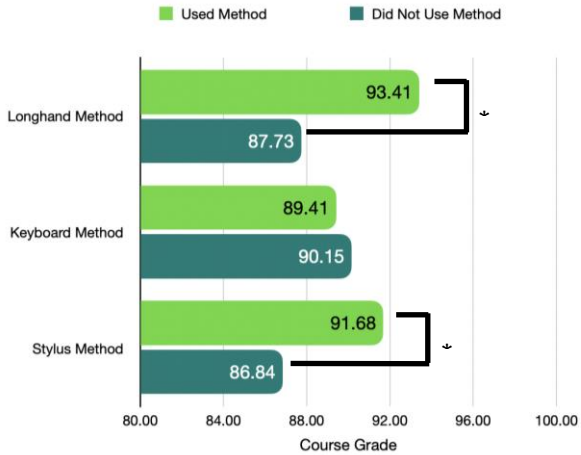
Percent of Students who Reported Using Each Note-taking Method Throughout the Semester



Note. Students were able to select multiple methods.

Figure 2

Course Grades for Students who Did versus Did Not Report Regularly Utilizing Each Note-taking Method



Note. Course grades are out of 100 points. Asterisk (*) indicates significant difference between those who reported using versus not using a particular method.

Perceived Engagement

Chi-square tests were used to identify whether students perceived different note-taking strategies as increasing their class engagement during the mini-lectures. There was a marginally significant difference in strategies students perceived as helping them stay engaged, $\chi^2(2) = 4.97$, $p = .083$ (Table 2). Pairwise comparisons revealed no differences between longhand and stylus, and students reported that they felt more engaged with the stylus, $\chi^2(1) = 4.27$, $p = .039$, and longhand (marginal), $\chi^2(1) = 3.81$, $p = .051$, compared to the keyboard.

Discussion

This study investigated the impact of three note-taking styles on performance and engagement in Introduction to Psychology courses. In the in-class experiment, there was no evidence that one single method led to better overall performance, but students did perform better when using their preferred note-taking methods. In contrast, over the semester, students who used longhand or stylus note-taking versus those who did not use each method performed better in the course. There were also differences in student perceptions that supported this finding, with longhand and stylus versus keyboard note-taking resulting in perceptions of better recall and class engagement during the mini-lecture. Thus, in an Introduction to Psychology class, longhand and stylus note-taking seemed to produce similar advantages over keyboard, although

student preference may influence the effectiveness of various note-taking methods.

Taken together, this evidence suggests the potential for overall benefits of longhand and stylus note-taking in academic performance in the classroom. Although there were no overall differences in mini-lecture recall scores, students who used longhand and stylus had better course grades, and students also perceived that longhand and stylus improved their recall in the mini-lectures. This finding corroborates previous evidence of small but consistent benefits to longhand compared to keyboard note-taking in both lab and classroom settings (e.g., Artz et al., 2020; Morehead et al., 2019; Mueller & Oppenheimer, 2014) and demonstrated similar benefits for stylus. When using longhand or stylus, students use similar muscles and movements to physically write notes. Additionally, because students cannot write fast enough to record content verbatim, they must paraphrase. This promotes deeper processing (Mueller & Oppenheimer, 2014) and may increase the recall of new information compared to other methods of note-taking. Students taking longhand or stylus versus keyboard notes may perceive better recall because they have thought more about the material; therefore, they believe they remember more. Thus, this study extends previous research by suggesting that stylus note-taking may provide benefits similar to

longhand for academic performance. These differences are also reflected in student perceptions.

In addition, this study demonstrated that note-taking style influences student perceptions of class engagement. Taking notes using longhand or stylus may encourage students to think about the material and use deeper processing as they are taking notes (Mueller & Oppenheimer, 2014), thus feeling more connected to the material. Conversely, the current evidence suggests that keyboard note-taking negatively impacted students' perceptions of their engagement. Although previous evidence found widespread non-academic use of technology during class (Ravizza et al., 2016), this study suggests that not all technology has equal impacts on disengagement. This could be because the more rapid note-taking using a keyboard (Luo et al., 2018; Morehead et al., 2019; Van Der Steen, 2017) increased non-academic behavior in a way that stylus note-taking did not. Although students in this study self-reported engagement, previous studies have found correlations between self- and teacher-reported class participation (Carstens et al., 2015). Thus, course grade and student self-report findings suggest some overall benefit to taking notes using longhand or stylus methods.

However, these findings also suggest that there may be substantial benefits to instructors letting students choose the methods that they are most comfortable with. In the more objective outcome of recall scores following the mini-lecture, the only

significant effect was that students performed best when using the note-taking strategies they typically used. This could have to do with familiarity with the method leading to better recall. For example, students who generally use the stylus have more practice and thus may take more effective notes, which benefits their recall. Preferences may also reflect individual differences in learning styles or strategies, such that some students benefit from writing more verbatim notes on a keyboard, while others benefit more from deeper processing using longhand or stylus. Taken together, these findings suggest that while instructors might consider encouraging students to explore using longhand or stylus note-taking, they could do students a disservice by requiring them to use one specific method.

Limitations and Future Directions

Several issues remain for future research. First, there were some basic methodological limitations to this study. The quiz score averages were quite high with little variability, so a ceiling effect may have masked any overall differences in the note-taking method, and a more comprehensive recall test might better identify group differences. In addition, using more complex recall tasks or inserting a delay before recall may amplify differences based on the note-taking method. Finally, because this study manipulated student note-taking within the context of the Introduction to Psychology course, it is possible that this manipulation could have

influenced students' note-taking outside of the experiment and their course performance. Although the study was conducted in the last few weeks of class and the manipulation was minimal, it would be important to replicate the mini-lecture experiment and overall course effects in separate samples.

Future studies could also explore additional questions to add to our understanding of this topic. For example, providing students opportunities to review their notes before testing could help further understand exactly how note-taking may influence the recall process. In addition, the quality and content of notes could be assessed to help understand how different strategies may lead to higher or lower quality notes or different noted content (i.e., verbatim words versus drawings). Nonetheless, this provides an important starting point for further exploration in the role of technology-assisted note-taking in the college classroom.

Conclusions

In conclusion, this study suggests that the stylus may confer similar benefits to longhand note-taking, particularly regarding student perceptions of performance and engagement. However, findings also demonstrate that it is also important for faculty to consider students' personal preferences and experience with various note-taking methods rather than requiring students to use one particular method. Furthermore, it suggests that campuses that offer similar technology initiatives may serve as a prime target for

investigating the impact of technology on learning, as uniform equipment can control for the variability in technology when students are asked to use their own. Although future work is needed to develop better assessments of recall and investigate the content and usage of notes, this study underscores the importance of investigating the stylus as a note-taking tool. These findings suggest that although instructors might encourage their students to try longhand or stylus note-taking, they should also allow students to use the style that best fits their personal preference. They also suggest that classroom technology bans could be detrimental to students who prefer technology-assisted note-taking methods.

References

Aguilar-Roca, N. M., Williams, A. E., & O' Dowd, D. K. (2012). The impact of laptop-free zones on student performance and attitudes in larger lectures. *Computers & Education, 59*, 1300-1308. https://doi.org/10.1016/j.compedu.2012.05.002

Artz, B., Johnson, M., Robson, D., & Taengnoi, S. (2020). Taking notes in the digital age: Evidence from classroom random control trials. *Journal of Economic Education, 51*, 103-115. https://doi.org/10.1080/00220485.2020.1731386

Bohay, M., Blakely, D. P., Tamplin, A. K., & Radvansky, G. A. (2011). Note taking, review, memory, and comprehension. *American Journal of Psychology, 124*, 63-73. https://doi.org/10.5406/amerjpsyc.124.1.0063

Carstens, B., Watson, T., & Williams, R. (2015). Unstructured laptop use in a highly structured entry-level college course. *Scholarship of Teaching and Learning in Psychology, 1*, 137-149. https://doi.org/10.1037/stl0000029

Carter, S. P., Greenberg, K., & Walker, M. S. (2017). The impact of computer usage on academic performance: Evidence from a randomized trial at the United States Military Academy. *Economics of Education Review, 56*, 118-132. https://doi.org/10.1016/j.econedurev.2016.12.005

Elliott-Dorans, L. (2018). To ban or not to ban? The effect of permissive versus restrictive laptop policies on student outcomes and teaching evaluations. *Computers & Education, 126*, 183-200. https://doi.org/10.1016/j.compedu.2018.07.008

Fiorella, L. & Mayer, R. E. (2017). Spontaneous spatial strategy use in learning from scientific text. *Contemporary Educational Psychology, 49*, 66-79. http://doi.org/10.1016/j.cedpsych.2017.01.002

Jansen, R. S, Lakens, D., & Ijsselsteijn, W. A. (2017). An integrative review of the cognitive costs and benefits of note-taking. *Educational Research Review, 22*, 223-233. https://doi.org/10.1016/j.edurev.2017.10.001

Luo, L., Kiewra, K., Flanigan, A., & Peteranetz, M. (2018). Laptop versus longhand note taking: Effects on lecture notes and achievement. *Instructional Science, 46,* 947–971. https://doi.org/10.1007/s11251-018-9458-0

Morehead, K., Dunlosky, J., & Rawson, K. (2019). How much mightier is the pen than the keyboard for note-taking? A replication and extension of Mueller and Oppenheimer. *Educational Psychology Review, 31,* 753-780. https://doi.org/10.1007/s10648-019-09468-2

Mueller, P., & Oppenheimer, D. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science, 25,* 1159–1168. https://doi.org/10.1177/0956797614524581

Osugi, K., Ihara, A., Nakajima, K., Kake, A., Ishimaru, K., Yokota, Y., & Naruse, Y. (2019). Differences in brain activity after learning with the use of a digital pen vs. an ink pen—an electroencephalography study. *Frontiers in Human Neuroscience, 13,* Article 275, 1-9. https://doi.org/10.3389/fnhum.2019.00275

Patterson, R. W. & Patterson, R. M. (2017). Computers and productivity: Evidence from laptop use in the college classroom. *Economics of Education Review, 57,* 66-79. https://doi.org/10.1016/j.econedurev.2017.02.004

Pfeuffer, K., Hinckley, K., Pahud, M., & Buxton, B. (2017). Thumb + pen interactions on tablets. *CHI '17: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 3254-3266. https://doi.org/10.1145/3025453.3025567

Ragan, E. D., Jennings, S. R., Massey, J. D., & Doolittle, P. E. (2014). Unregulated use of laptops over time in large lecture classes. *Computers & Education, 78,* 78-86. https://doi.org/10.1016/j.compedu.2014.05.002

Rahim, N. & Meon, H. (2013). Relationships between study skills and academic performance. *AIP Conference Proceedings, 1522,* 1176. https://doi.org/10.1063/1.4801264

Ravizza, S., Uitvlugt, M. & Fenn, K. (2016). Logged in and zoned out: How laptop internet use relates to classroom learning. *Psychological Science, 28,* 171-180. https://doi.org/10.1177/0956797616677314

Smoker, T. J., Murphy, C. E., & Rockwell, A. K. (2009). Comparing memory for handwriting versus typing. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 53,* 1744-1747. https://doi.org/10.1177/154193120905302218

Van Der Steen, S., Samuelson, D., & Thomson J. M. (2017). The effect of keyboard-based word processing on students with different working memory capacity during the process of academic writing. *Written Communication, 34,* 280-305. https://doi.org/10.1177/0741088317714232

van Wyk, M. & van Ryneveld, L. (2018). Affordances of mobile devices and note-taking apps to support cognitively demanding note-taking. Education and Information Technologies, *23,* 1639-1653. https://doi.org/10.1007/s10639-017-9684-0

Wollscheid, S., Sjaastad, J., Tømte, C., & Løver, N. (2016). The effect of pen and paper or tablet computer on early writing - A pilot study. *Computers & Education, 98,* 70-80. https://doi.org/10.1016/j.compedu.2016.03.008