Note-Taking Mode and Academic Performance in Two Law School Courses

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I. Introduction

Laptop use by students in law school classes has become commonplace, for several reasons. Many law students are digital natives who prefer to take notes on their laptop rather than handwrite. For students covered by Section 504 of the Rehabilitation Act,[1] laptop use in class may be a requirement of their educational accommodations. Some law schools may require their students to have a laptop.

Yet there may be detrimental effects associated with students' laptop use in law school classes. Several published studies in other higher education settings have shown negative effects on academic performance of student computer use during classes.[2] However, while descriptive reports and

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1. 42 U.S.C. §§ 12101-12213 (2012). A contemporaneous study argues for the abolition of laptop bans in law school classrooms on the basis of its benefits for students covered by Section 504 and the Americans with Disability Act. *See* Ruth Colker, *Universal Design: Stop Banning Laptops!*, 39 Cardozo L. Rev. 483 (2018).

2. *See, e.g.*, Arnold L. Glass & Mengxue Kang, *Dividing Attention in the Classroom Reduces Exam Performance*, Educ. Psych. (2018), https://doi.org/10.1080/01443410. 2018.1489046; Susan P. Carter et al., *The Impact of Computer Usage on Academic Performance: Evidence from a Randomized Trial at the United States Military Academy*, 56 Economics of Educ. Rev. 118 (2017); Richard W.

normative arguments have been made about the use of laptops to take notes in the law school classroom, the difference in academic performance between handwriters and computer users in the law school context has not been the subject of systematic study.[3]

In this article, we compare the academic performance of handwriters and computer users in two required doctrinal courses in the second year of law school.[4] We chose to study second-year students so that those in the study would have had the same 1L curriculum, thus mitigating the influence of students' prior educational backgrounds on their performance in the two courses that were the subject of the study.[5] We focused on the required doctrinal courses in the 2L fall semester, because these courses assessed students on the same types of academic skills that they developed in their first-year doctrinal courses and because these two courses followed closely on the heels of the required first-year curriculum.

We used multiple analytic methods in our study. First, we performed a descriptive analysis to demonstrate the composition of the sample. Next, we utilized associational methods to investigate the relationship between note-taking mode and academic performance. To isolate the impact of note-taking mode on academic performance and to remove "endowment effects," or the statistical bias caused by differences among students' inherent abilities, we controlled for LSAT scores.[6] We found that, after controlling for LSAT scores, students who handwrote their notes had a higher combined GPA for the fall 2L required courses than laptop users. This general result was consistent across a variety of descriptive and associational methodologies. Finally, using quasi-experimental estimation methods, we found that handwriting had a positive and statistically significant impact on academic performance in the two law

Patterson & Robert M. Patterson, *Computers and Productivity: Evidence from Laptop Use in the College Classroom*, 57 Economics of Educ. Rev. 66, 76 (2017); Nancy M. Aguilar-Roca et al., *The Impact of Laptop-Free Zones on Student Performance and Attitudes in Large Lectures*, 59 Computers & Educ. 1300, 1300 (2012).

3. *Cf.* Kimberly Ann Morse, *Before You Ban: Law Students' In-Class Laptop Usage and Academic Performance* (2016), https://search.proquest.com/openview/d37d3574d11800a2f758d217cc803540/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y (unpublished Ph.D. dissertation, St. Louis University). Morse studied the actual frequency of law students' off-task laptop behavior and the possible impact of off-task behavior on learning as measured by final course grade. Her study did not compare handwriters and laptop users.

4. The study encompassed the fall 2016 Constitutional Law I and Evidence courses, with two sections each, at Roger Williams University School of Law (RWU Law).

5. The first-year curriculum at RWU Law is Civil Procedure I & II, Contracts I & II, Criminal Law, Legal Practice I & II, Property, and Torts. Some students in the study may have taken summer law school courses after their first year of law school.

6. We use LSAT scores, because the LSAT assesses critical reading, verbal reasoning, and analytical thinking untethered from any particular subject matter on which class notes would be helpful. We elected not to control for undergraduate GPA or law school 1L GPA because either could have been affected by the very factor we were trying to isolate—whether note-taking mode correlated to academic performance.

school courses, which is consistent with other studies in the higher education setting.

Part I of this article reviews prior studies in the higher education context on the correlation between note-taking mode, learning, and academic performance. Part II explains the methodologies employed in our study, and Part III details our findings.

II. Prior Studies on Note-Taking Mode, Learning, and Academic Performance

Several researchers have studied how computer use by university-level students in the laboratory or classroom might affect learning.[7] The laboratory studies comparing performance of those who took notes by hand and those who took notes by computer have produced mixed results on short-term factual recall, while a laboratory study of short-term conceptual application showed handwriters significantly outperformed computer users. The classroom studies have consistently shown adverse effects on academic performance when students are permitted to use computers in the classroom.

A. Laboratory Studies Connecting Note-Taking Mode to Learning

Studies conducted in laboratory settings have compared short-term learning of handwriters and computer users who had taken notes while listening to a short lecture.[8] In these laboratory studies, the subjects did not have access to the Internet, the researchers randomly assigned students to a particular note-taking mode, and subjects were tested from within minutes to one week after taking their notes.[9] On short-term factual recall, laboratory studies have produced mixed results regarding the learning of handwriters versus computer users.[10]

7. *See, e.g.*, Glass & Kang, *supra* note 2; Carter et al., *supra* note 2; Patterson & Patterson, *supra* note 2; Pam A. Mueller & David M. Oppenheimer, *The Pen is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking*, 25 Psychol. Sci. 1159 (2014); K.M. Beck et al., *Notetaking Effectiveness in the Modern Classroom,* 1 The Compass 9 (2014), http://scholarworks.arcadia.edu/thecompass/vol1/iss1/9; Dung C. Bui et al., *Note-taking with Computers: Exploring Alternative Strategies for Improved Recall*, 105 J. Educ. Psych. 299 (2013); Aguilar-Roca et al., *supra* note 2.

8. *See, e.g.*, Mueller & Oppenheimer, *supra* note 7; Beck et al., *supra* note 7; Bui et al., *supra* note 7.

9. *Id*.

10. In studies that did not allow the participants to review their notes before testing within minutes to a week of note taking, one study found that computer users outperformed handwriters, while other studies found that there was no statistically significant difference in performance between handwriters and computer users. *Compare* Bui et al., *supra* note 7 (finding computer note takers outperformed handwriters in study of eighty undergraduate participants who were tested immediately after listening to an eleven-minute lecture that consisted of a passage from a nonfiction book and who were not allowed to review their notes), *with* Mueller & Oppenheimer, *supra* note 7, at 1166 (reporting that in immediate testing of factual recall and no student review of notes prior to testing, laptop users and

On conceptual application, however, a laboratory study conducted at Princeton University and the University of California-Los Angeles by Mueller and Oppenheimer showed that handwriters significantly outperformed computer users.[11] The Mueller and Oppenheimer study is of particular salience to legal education, because conceptual application is a highly-emphasized element of "thinking like a lawyer"—what every law school trains its students to do. The Mueller and Oppenheimer study yielded two key findings relating note-taking mode and learning. First, the study showed that even when students used computers only for note-taking purposes and not for distracting purposes, the use of the computer still resulted in shallower cognitive processing, negatively affecting learning.[12] Second, this study found that that a greater number of notes positively predicted learning, but also that computer note takers' tendency to take transcription-like notes was detrimental to learning. This is because note taking that processes information and reframes it into students' own words improves learning, and this process was more frequently observed with handwriters.[13]

B. Classroom Studies Connecting Note-Taking Mode to Academic Performance

Studies of semester-long courses have documented the distractive effects of students' use of computers in the classroom.[14] For example, in a study of

handwriters performed equally well) *and* Beck et al., *supra* note 7 (finding no statistically significant difference in testing performance between handwriters and computer note takers in a study of twenty-one undergraduates who watched a nine-minute video lecture on an ancient artifact, took notes according to their randomly assigned note-taking mode, and were immediately tested with twenty multiple-choice questions on the content of the video without being able to review their notes; same finding when students were tested a week later without being able to review their notes). However, in a study that did allow some participants to review their notes for ten minutes before testing that occurred a week after taking the notes, handwriters who were able to review their notes significantly outperformed on factual-recall questions both handwriters who were not able to review their notes and computer users who had or had not been able to review their notes. Mueller & Oppenheimer, *supra* note 7, at 1164.

11. Mueller & Oppenheimer, *supra* note 7. The highly-publicized research by Mueller and Oppenheimer tested not only factual recall but also conceptual application. Their research showed that a greater number of notes positively predicted academic performance, but that laptop note takers' tendency to take transcription-like notes was detrimental to academic performance. Note taking that processes information and reframes it into students' own words improve academic performance, and this was more likely with handwriters. *Id.* at 1159, 1166. The Mueller and Oppenheimer research showed as well that even when laptop users were instructed to "[t]ake notes in your own words and don't just write down word-for-word what the speaker is saying," laptop users took notes in a verbatim fashion to their detriment. *Id.* at 1164.

12. *Id.* at 1159.

13. *Id.* at 1159, 1166. The Mueller and Oppenheimer study also showed that even when laptop users were instructed to "[t]ake notes in your own words and don't just write down word-for-word what the speaker is saying," laptop users took notes in a verbatim fashion to their detriment. *Id.* at 1164.

14. *See, e.g.*, Susan M. Ravizza et al., *Logged In and Zoned Out: How Laptop Internet Use Relates to*

computer use at a law school, in four upper-level courses, fifty-eight percent of the computer users employed their laptops for non-class purposes for at least half the class time, and eight-seven percent for more than five minutes.[15] Several classroom studies have demonstrated a negative correlation between off-task laptop usage and academic performance.[16] Other classroom studies have shown that using a computer device for class-related purposes does not, on average, improve academic success.[17]

In light of the laboratory research showing that conceptual application may be negatively affected by note-taking mode—apart from any off-task computer behavior—we focus now on four recent classroom studies that examined the effects of student computer use in the classroom on academic performance. These four studies are comparable to ours in that they examined the cumulative effects of Internet-enabled classroom technology over the course of a semester or multiple semesters, but they did not take into account how students used computers during class.[18]

In a 2012 published study of over 1600 mostly first-quarter freshmen in four sections of an introductory biology course at the University of California, Irvine, researchers found that "paper note takers scored significantly higher and laptop users scored significantly lower [on midterm and final exam scores]

Classroom Learning, 28 Psychological Sci. 171, 174 (2016) (finding, in a classroom study of students in an introductory psychology class in which participants logged onto a proxy server to monitor their online activity during class, that participants spent a median of 37 minutes per class browsing the Internet for non-class related purposes; classes were 1 hour and 50 minutes with 10-minute break in the middle); Jeff Sovern, *Law Student Laptop Use During Class for Non-Class Purposes: Temptation v. Incentives*, 51 U. of Louisville L. Rev. 483 (2013).

15. Sovern, *supra* note 14, at 492, 494.

16. *See, e.g.*, Ravizza et al., *supra* note 14 (finding, in a classroom study of students in an introductory psychology class in which participants logged onto a proxy server to monitor their online activity during class, that, after accounting for ACT scores, nonacademic Internet use was inversely related to performance on the final exam); Patrick Gaudreau et al., *Canadian University Students in Wireless Classrooms: What Do They Do on Their Laptops and Does It Really Matter?*, 70 Computers & Educ. 245 (2014) (finding that "[h]igher usage [of laptops for purposes unrelated to school] during the semester was related to lower end of semester grade point average . . . and to lower performance relative to other students enrolled in the same courses," with laptop usage behaviors self-reported by participants; results held even after controlling for self-reports concerning self-regulation failure, motivational deficit, disorganized learning, Internet addiction, and school disenchantment); s*ee also* James M. Kraushaar & David C. Novak, *Examining the Affects of Student Multitasking with Laptops During the Lecture*, 21 J. Info. Systems Educ. 241 (2010); Carrie B. Fried, *In-Class Laptop Use and Its Effects on Student Learning*, 5 Computers & Educ. 906 (2008); Michael Grace-Martin & Geri Gay, *Web Browsing, Mobile Computing, and Academic Performance*, 4 Educ. Tech. & Soc. 95 (2001).

17. *See, e.g.*, Ravizza et al., *supra* note 14 (finding that class-related Internet usage—such as logging onto the class website or searching for extra information on Wikipedia—did not benefit performance on the final exam); Patrick Gaudreau et al., *supra* note 15 (finding that "school related laptop behaviors were mostly unrelated to academic success of students").

18. *See* Susan P. Carter et al., *supra* note 2; Patterson & Patterson, *supra* note 2; Aguilar-Roca et al., *supra* note 2.

than predicted" by pre-class academic indicators.[19] Classrooms were Internet-enabled, and students were able to choose whether they would take class notes by hand or by laptop.[20] In this study, students registered their note-taking mode by answering a multiple-choice question on both their midterm and final exams on whether they handwrote or typed on a laptop during class.[21] Some of the students provided comments in the free-response section of the final exam about why they chose their note-taking mode; students' responses were coded into three categories: "easy/convenient," "facilitates learning," and "other." For paper note takers, "facilitates learning" was the principal reason for using paper, while laptop users cited "convenience" as the principal reason for taking notes by laptop.[22]

The main purpose of the UC Irvine study was to examine the impact of laptop-free zones within a large lecture hall on academic performance and student attitudes. Although they found that handwriters scored significantly higher and laptop users scored significantly lower than pre-class academic indicators, the researchers noted that they did not "have information that addresses whether there was a causative [sic] relationship between laptop use and performance."[23]

Unlike the UC Irvine study, which was unable to address whether a causal relationship existed between laptop use and performance, a 2017 study by Patterson and Patterson asserted "that computer use has a [causally]

19. *See* Aguilar-Roca et al., *supra* note 2. The pre-class academic indicators considered were a first-day concept assessment quiz, composite SAT scores, and scores of 3 or higher on the AP Biology Test. *Id.* at 1301. Most of the students in the introductory biology classes were first-quarter freshmen. *Id.* at 1306.

20. *Id*. at 1303.

21. Aguilar-Roca et al., *supra* note 2. Students were asked on the midterm and on the final exam, "What is your primary method of taking notes in this class?" with the following options:
    a. Handwritten on printouts of the PowerPoint slides
    b. Handwritten on notepaper
    c. Typed on a laptop directly into PowerPoint
    d. Typed on a laptop using other software (e.g., Word, OneNote)
    e. I rarely took notes.

    Id. at 1302. In responding to this question on both the midterm and the final exam, approximately fifty percent of the students consistently reported they took notes on paper and approximately twenty-two percent of the students consistently reported they used laptops to take notes. The remaining students were excluded from further analyses of in-class performance data. *Id.* at 1303-04.

22. *Id*. at 1303.

23. *Id*. at 1304; *see also id*. at 1306 (noting the consistency of their findings with "a growing number of studies that correlate lower performance to in-class laptop use" but stating that "none of these studies (including ours) establishes a causative [sic] link between laptop use and performance"); *id*. at 1307 ("Because the variable we manipulated in this study was zoning [in the classroom], not laptop use, the underlying causes for why laptop users underperformed are not known."). We used "[sic]" in the quotations from the UC Irvine study because the relationship described by the UC Irvine researchers is more typically referred to as a "causal" relationship.

significant negative impact on course performance."[24] This study analyzed academic performance of 5571 undergraduate and master's degree students at a private liberal arts college over multiple semesters and across a broad range of courses in which laptop use was optional, required, or banned.[25] This study sought to examine factors affecting laptop use and to compare "the grades of students who are and are not influenced to bring computers to class by their course schedules."[26] The researchers found that having a laptop-required class on the same day as a laptop-optional class increased the probability that a student used a laptop in the laptop-optional class by 20.6%; having a class that prohibited laptop use on the same day as the laptop-optional class decreased the probability of using a laptop in the laptop-optional class by 48.9%.[27] The researchers produced estimates suggesting that "computer use decreased grades between 0.14 and 0.37 grade points."[28] The researchers concluded that "laptop use directly worsens academic outcomes for students who choose to use them."[29]

While the UC Irvine and the Patterson and Patterson studies analyzed performance at the individual level within classrooms, a 2017 study of 726 sophomores enrolled at the United States Military Academy analyzed performance at the classroom level. In this study, students in a multisection introductory economics course were randomly assigned to one of three types of course sections: "technology-free" (students could not use laptops or tablets during class); "unrestricted technology" (students could use laptops or tablets or both); and "modified tablet" (students could use tablets, but the tablets had to remain flat on the desk with the screen facing up, allowing the professor to monitor usage).[30] These three types of sections were similar in terms of student demographic characteristics, baseline GPAs, and ACT scores.[31] The sections of the economics course had roughly fifteen students each, and the sections were standardized in terms of syllabus, required materials, and a final exam that consisted of a combination of multiple-choice, short-answer, and essay questions.[32]

24. Patterson & Patterson, *supra* note 2, at 76.

25. *Id.* at 67, 71.

26. *Id.*

27. *Id.* at 72.

28. *Id.* at 67.

29. *Id.* at 77. Among other qualifications, the researchers noted that "our study isolates the impact of laptop use on the students who are on the margins of using a laptop in class," and that it "is possible that students who always use laptops in class could still benefit from use while those on the margins suffer." *Id.* at 76-77.

30. Carter et al., *supra* note 2 at 119, 120-21. Students in the modified-tablet and unrestricted-technology classrooms were not required to use laptops or tablets. *Id.* at 119.

31. *Id.* at 121-22.

32. *Id.* at 123.

The researchers found that average final exam scores among students randomly assigned to sections that allowed computers were roughly 0.2 standard deviations lower than scores of students randomly assigned to sections that prohibited computers.[33] However, the study did not directly compare handwriters and computer users. As such, it is not possible to determine how handwriters' performance compared with computer users' performance in the two types of sections that allowed computing devices.

While the researchers in the West Point study were able to conclude that "students perform worse when computers are available," they did not test for the possible reasons for this outcome, such as whether computer use leads to worse note taking or more distractibility or whether professors teach differently when students use computers.[34] However, what is clear from the study is that average performance on the final exam was lower for students in sections that permitted computing devices than for students in sections that prohibited computing devices. Moreover, the researchers found that the results were nearly identical for the unrestricted-technology sections as for the modified-tablet sections.[35] Interestingly, the West Point study found that permitting laptops or tablets in the classroom reduced scores on multiple-choice and short-answer questions on the final exam (both types of questions were computer-graded) but did not reduce essay scores on the final exam (essay questions were instructor-graded).[36]

Most recently, a study of 118 psychology students at Rutgers University allowed students to use electronic devices during half the lectures in two sections of an upper-level cognitive psychology course but banned use of electronic devices for the other lectures; the study found that student performance on unit exams and the final exam was poorer for all students

33. Carter et al., *supra* note 2. The introductory economics course was offered in two semesters, with fifty sections total of approximately fifteen students each. *Id.* at 122. As to whether the West Point findings on the negative effects of computer use in the classroom might translate to other higher education settings, the researchers stated: "It is quite possible that these harmful effects could be magnified in settings outside of West Point. In a learning environment with lower incentives for performance, fewer disciplinary restrictions on distracting behavior, and larger class sizes, the effects of Internet-enabled technology on achievement may be larger due to professors' decreased ability to monitor and correct irrelevant usage." *Id.* at 128.

34. *Id.* at 129.

35. *Id.* at 125.

36. *Id.* at 124. The researchers commented that the essay questions were "conceptual in nature" and that the "zero effect for essay questions . . . stands in contrast to previous research by Mueller and Oppenheimer . . . who demonstrate that laptop note-taking negatively affects performance on both factual and conceptual questions." The West Point researchers speculated that the zero effect on essay questions might result from "the predominant use of graphical and analytical explanations in economics courses, which might dissuade the verbatim note-taking practices that harmed students in Mueller and Oppenheimer's study." *Id.* at 124-25. The West Point researchers also commented that "considering the substantial impact that professors have on essay scores, [the zero effect of computer note taking on essay-question performance] should be interpreted with considerable caution." *Id.* at 125.

on the tested material previously covered on device-approved days compared with the tested material previously covered on device-banned days.[37] This effect held regardless of students' individual decisions on whether to use their electronic devices on the device-approved days. (At the end of each class session during which electronic devices were permitted, students answered whether they looked at their laptop or phone during that class session.)

The design of the study was intricate. The same professor taught both sections of the upper-level psychology course, with both sections receiving the same lectures, quizzes, and exams. There was complete redundancy between the textbook and the lectures so that the answer to every exam question was presented both in the textbook and on PowerPoint slides.[38] During the semester, students answered multiple-choice questions in class that tested just-presented content on the previous PowerPoint slide; students had ten seconds to respond, and they submitted their responses through personal-response software. The professor then displayed the correct answer and entertained any questions about it. Over the course of the semester, the professor administered 126 multiple-choice questions during class; each classroom question was subsequently paired with another question on both a unit exam and the final exam, with the same principle or fact statement implying both the answer to the classroom question and the answer to the exam question.

In terms of specific findings, the study showed that the device-allowed days did not adversely affect performance on in-classroom questions but did adversely affect subsequent exam performance, with the largest effect on the final exam.[39] The study showed a five percent decrease in performance (a "meaningful amount") on tested material that had been previously covered during device-allowed days. The study authors asserted that their "finding demonstrates for the first time that the main effect of divided attention in the classroom is not an immediate effect of selection or switching on comprehension but a long-term effect of divided attention on retention."[40]

Another important finding of the Rutgers study is that the adverse effect on subsequent exam performance with respect to material presented on device days applied both for students who used an electronic device and for students who did not. This finding indicates the adverse effect on student performance of other students' use of electronic devices in the classroom, and it confirms an earlier laboratory study showing the distractive effect of others' use of electronic devices.[41]

37. Arnold L. Glass & Mengxue Kang, *Dividing Attention in the Classroom Reduces Exam Performance*, Educ. Psych. (2018), https://doi.org/10.1080/01443410.2018.1489046.

38. The PowerPoint lecture slides were presented to students during class meetings and were also available to the students on the course website. *Id.*

39. *Id.*

40. *Id.*

41. *Id.*

In sum, in four recent studies at the university level, researchers found that the presence of student computing devices in the classroom negatively affected academic performance. In three studies, the negative effect was shown at the individual level within classrooms, and in one study, the negative effect was shown at the classroom level. These behavioral study results are perhaps unsurprising in light of neuroscience studies showing that the brain not only suffers from "multitasking" as opposed to "single tasking,"[42] but that the brain activates differently according to whether a study participant is handwriting or typing.[43]

Our study, which compares academic performance at the individual level within law school classrooms, shows that laptop usage in the classroom is associated with lower course grades, with those grades based principally on final exam essays.[44] In our discussion below, we will address first our methodology and then our specific findings.

42. *See, e.g.*, Marcel A. Just & Augusto Buchweitz, *What Brain Imaging Reveals About the Nature of Multitasking*, *in* Oxford Handbook of Cognitive Science (Susan E.F. Chipman ed., 2007) (reviewing brain imaging studies and stating that "one inescapable aspect of multitasking is that it comes at a cost. Mental resources, like any other biological resources, are limited, and when they are distributed among the various functions that constitute multitasking, the ultimate cognitive performance in the component tasks is compromised"); Menno Nijboer, et. al, *Single-task fMRI Overlap Predicts Concurrent Multitasking Interference*, 100 NeuroImage 60 (2014) (referring to multitasking "interference" as the "cost of simultaneous performance of multiple tasks as compared to doing only one task at a time" and reporting results of functional magnetic resonance imaging (fMRI) study indicating that "multitasking interference is not due to a bottleneck in a single 'multitasking' brain region, but is a result of interactions between concurrently running processes"). An article targeted at the legal education community that provides a helpful overview of neuroscience and cognitive science findings with respect to multi-tasking and attention is James B. Levy, *Teaching the Digital Caveman: Rethinking the Use of Classroom Technology in Law School*, 19 Chapman L. Rev. 241, 256-69, 279-83 (2016).

43. *See, e.g.*, Audrey L.H. van der Meer & F.R. van der Weel, *Only Three Fingers Write, but the Whole Brain Works: A High-Density EEG Study Showing Advantages of Drawing Over Typing for Learning*, 8 Front. Psychol. Article 706 (2017) (finding "direct electrophysiological evidence [in young adults] that drawing by hand activates larger networks in the brain than typing on a keyboard" and that the type of brain activity found when drawing by hand "provides optimal conditions in the brain for learning"; the researchers assumed, based on prior research, "that handwriting and drawing with a pen, in general, involve similar brain activity"); Jean-Luc Velay & Marieke Longcamp, *Handwriting versus Typewriting: Behavioural and Cerebral Consequences in Letter Recognition*, *in* 25 Learning to Write Effectively: Current Trends in European Research Studies in Writing 371 (Denis Alamargot et al. eds., 2012) (teaching adults in the study to produce sets of unknown characters and finding, through functional magnetic resonance imaging (fMRI), that "the difference in recognition performance between characters learned by handwriting and characters learned by typewriting is related to different neural pathways").

44. The West Point study compared performance at the classroom level, while our study compared performance at the individual level within classrooms.

III. Methodology

A. Study Overview

Our study accounts for differences in LSAT scores while analyzing two principal relationships: (1) the relationship between note-taking mode and academic performance; and (2) the relationship between exposure to a memorandum about the possible pitfalls of using a laptop to take class notes and academic performance. To measure the first relationship, we examined whether a student's choice of note-taking mode resulted in increased academic performance in the fall 2016 sections of Constitutional Law I and Evidence—the only required doctrinal courses in the fall 2L semester at the law school.[45] To measure the second relationship, we exploited the random assignment process of first-year students at our law school to two sections of civil procedure—one taught by an author of this article, Colleen P. Murphy, who required students who were considering using a laptop in class to read her memorandum that advised against using a laptop to take class notes and discussed the possible deleterious effects of laptop usage.[46] We now turn to how we collected and analyzed the relevant data.

B. Data Collection

At the beginning of the fall 2016 semester, the four professors of the required 2L doctrinal courses requested that their students visit a project site—called "Constitutional Law and Evidence Class Notes Survey"—on the university's open-source course management system. The project site informed students that "[f]aculty within the university are conducting a study of student note-taking methods in the law school's Constitutional Law and Evidence classes," but the site did not give further details about the purpose of the study. The

45. The courses were taught in two sections each, with a different professor teaching each section. Students had free choice on their note-taking mode, and they had access to the Internet in their classrooms. The final course grade in the four sections was principally based on an anonymously graded final exam that included an essay question or questions, and, in two sections, also shorter open-ended questions. For three of the four sections, professors based the final course grade on the final exam, with the possibility of adjustment by a plus or minus based on class participation. In one course section, the professor based the final course grade on written exercises worth ten percent, a final exam, and the possibility of an adjustment by a plus or minus based on class participation. In three of the four sections, students could bring their class notes (among other materials) to the final exam. In the fourth section, students could not bring any materials to the final exam. Constitutional Law I was a three-credit class and Evidence was a four-credit class, so our study gave proportional weighting in calculating what we call the "Con Law I/Evidence GPA" or "2L GPA" throughout this article.

46. First-year students are randomly assigned to first-year courses. However, three students who did not receive the memorandum as first-year students were enrolled as second-year students in Murphy's fall 2016 Remedies course and did receive the memorandum in their second year of study. As such, these students' observations were dropped from the quasi-experimental analysis but were included in the descriptive and associational analyses below, not only for statistical power but also because the effect of the memorandum is not germane to the descriptive and associational analyses.

project site prompted students to answer: "Will you be using a laptop to take class notes?" for each of their two course sections. The project site also instructed students to register on the site if they changed their note-taking mode during the semester. No students indicated on the project site that their note-taking mode changed during the semester.

Out of 122 second-year students enrolled in the fall 2016 Constitutional Law I and Evidence courses, 119 students registered on the project site as to whether they would be handwriting or using a laptop to take class notes in their sections of Constitutional Law and Evidence.[47] Out of those 119 students, 113 explicitly indicated that they would use the same note-taking mode in both classes. We excluded from our statistical analyses six students—two who indicated that they handwrote class notes in one course but used a laptop to take class notes in the other course, and four who registered their note-taking mode in one course but not in the other course. Thus, for purposes of the descriptive and associational analyses that follow, the analytic sample comprised the 113 students who indicated they would use the same note-taking mode in both Constitutional Law I and Evidence.[48] Within the analytic sample, the average LSAT score was 149, and the average undergraduate GPA was 3.16.

We divided this sample into four cohorts for statistical analyses: "Memo/Handwriters," "Memo/Laptop Users," "Non-Memo/Handwriters," and "Non-Memo/Laptop Users." The two "Memo" cohorts consisted of students who were enrolled in Murphy's course either in first-year Civil Procedure I and II during the academic year 2015-2016 (the academic year before the study population was enrolled in Constitutional Law I and Evidence) or in Remedies during fall 2016 (when the study population was also enrolled in Constitutional Law I and Evidence). As part of Murphy's laptop usage policy beginning in the fall 2015 semester—many months before the idea for this study was conceived—Murphy required all her students who were considering using a laptop in class to read her memo that advised against using a laptop, discussed possible pitfalls of laptop usage in the classroom, and stated her laptop usage policy. The "Non-Memo" cohorts consisted of all other students in the study's analytic sample. We separated the analytic sample into the Memo and Non-Memo cohorts to avoid any bias to the study estimates that might result from the fact that one group had received a memo on the possible deleterious effects of laptop use in the classroom while the other group had not.[49] Three students who were not enrolled in Murphy's Civil Procedure

47. Student responses to the questionnaire were accepted through September 9, 2016.

48. The analytic sample size for this study, 113 of 122 total second-year law students, is in fact quite large, not only as a proportion of the total second-year law students at Roger Williams University School of Law, but as a total number of participants when compared with other studies. *See* Beck, *supra* note 7 (with twenty-one participants); Mueller & Oppenheimer, *supra* note 7 (with sixty-seven, 151, and 109 participants, respectively, in three studies); Bui et al., *supra* note 7 (with eighty, seventy-six, and seventy-two participants, respectively, in three experiments).

49. Nearly all of the students in the Memo group received the memo in their first-year Civil Procedure course with Murphy (fifty-five of the fifty-eight students in the Memo group).

course in the academic year 2015-2016 received the memorandum for the first time in Murphy's fall 2016 Remedies course; these three students registered as handwriters in our study. In our associational and descriptive analyses, which are reported in Tables 1-4 below, we kept these three students in the sample for statistical power.[50] However, we dropped these three students from the sample in our quasi-experimental analysis, because randomized receipt of the memorandum was essential to that analysis.

The numbers of students in the four cohorts are set forth below in Table 1.

Table 1. Handwriters and Laptop Users in Con Law I/Evidence

Cohort	Number of Students
Memo/Handwriters	31
Memo/Laptop Users	27
Non-Memo/ Handwriters	15
Non-Memo/Laptop Users	40

Based on these numbers, students in the analytic sample who had received the memo on the possible pitfalls of laptop use either the year before in Murphy's Civil Procedure course or in her fall 2016 Remedies course[51] were

In Murphy's Remedies course, eight 2L students were simultaneously enrolled in the Constitutional Law I and Evidence courses that were the subject of our study. Of these eight students, five had previously received the memo in Murphy's Civil Procedure course the year before, and three received the memo from Murphy for the first time. Although it is possible that the memo could have been shared with some Non-Memo students in the 1L year or in the beginning of the 2L year, any possible sharing would have had minimal impact at most on the choices of Non-Memo students to handwrite or use a laptop to take class notes in Constitutional Law I and Evidence. Non-Memo students were far less likely to handwrite in the 2L courses than Memo students (fifteen versus thirty-one students), and because students registered their note-taking mode early in the fall of their second year of study, it is unlikely that the information diffused between Memo and Non-Memo students in the fall 2017 semester, which is the semester of interest in this study.

50. Because the receipt of the memorandum is not essential to the descriptive or associational analyses but is essential to the random-assignment requirement of the difference-in-differences analysis, these three students were kept in the sample for the descriptive or associational analyses but were removed from the sample for the difference-in-differences analysis.

51. In the fall 2016 Remedies course, only three 2L students had not taken Civil Procedure with

roughly twice as likely to handwrite in Constitutional Law I and Evidence as those who had not received the laptop memo.[52] These descriptive findings suggest that the laptop memo may have played a role in some students' choice of note-taking mode in courses beyond those courses in which students received the memo.

We provided the results of the online questionnaire of note-taking mode to the registrar/director of Student Finance & Records ("registrar") at the law school. After the Constitutional Law I and Evidence professors submitted their final course grades to Student Finance & Records, the registrar matched the student's name and note-taking mode with the student's LSAT score, 1L GPA,[53] final course grades in Constitutional Law I and Evidence, and designation, if applicable, as a student in Murphy's Civil Procedure course the year before or in her fall 2016 Remedies course. The latter information was necessary to enable separation of students who had received the laptop memo from those who had not. The registrar removed the names of all students before providing the aggregated data to us.

C. Data Analysis

We conducted both associational and quasi-experimental estimation methods in our analysis of the student-level data provided to us by the registrar. For the analysis reported in the first four tables, dependent sample *t* tests were employed to determine whether there was a statistically significant difference in the means of the variables tested. We used the sample of 113 students, including the three students who received the laptop memorandum for the first time in Murphy's fall 2016 Remedies course. Our quasi-experimental analysis used a difference-in-differences methodology, in which treatment and control groups were both random and balanced on LSAT score. We used a sample of 110 students, having removed from the sample the three students who received the memorandum for the first time in Murphy's fall 2016 Remedies course.[54] The analysis from this methodology proffered causal results on the effect of receiving the memo on academic performance as a means to more precisely attribute the role handwriting notes played in improved academic performance. We note that while this study has a very high degree of internal validity,[55] our results may not be generalizable to the entire population of law

Murphy the prior academic year. However, five students who were enrolled in Murphy's Remedies course as second-year students were also enrolled in her Civil Procedure course as first-year students. For any of these eight students, there is no concern of cross-contamination for purposes of the associational and quasi-experimental analyses, as they were all classified as having received the memorandum.

52. Murphy did not teach any section of Constitutional Law I or Evidence.

53. The 1L GPA did not include grades in any courses taken in the summer between the 1L and 2L years.

54. Our description of the difference-in-differences analysis is at notes 60 to 63 and accompanying text.

55. With regard to use of the memo, the only possible threat to the internal validity of the

students. However, because we find academic performance gains accruing to handwriters consistent with other studies at the undergraduate level, our results may be generalized to other law school settings with similar student profiles. The results from our study follow below.

IV. Results and Discussion

In our initial exploration of the data, we sought to control for individual differences among students, including controlling for each student's LSAT score. Thus, the first step in our analysis was to examine whether a student's LSAT score correlated with the student's Con Law I/Evidence GPA. By way of context, the Law School Admissions Council ("LSAC") reported in 2016 that the median correlation for all law schools between LSAT and 1L GPA was 0.41.[56] The most recent three-year correlation study that LSAC produced for Roger Williams University School of Law, which includes our analytic sample, showed that the correlation between LSAT and 1L GPA was 0.47.[57]

We found that in three of the four cohorts in our study, LSAT score correlated with the Con Law I/Evidence GPA at 0.44 and above, indicating that the LSAT had roughly the same or slightly greater positive association with Con Law I/Evidence GPA as it had for 1L GPA. The correlation for the fourth cohort—students who had not received the laptop memo but chose to handwrite in their fall 2L required courses—was only 0.2, likely because this this cohort of handwriters on average outperformed its LSAT score. In all cohorts, the mean differences between the Con Law I/Evidence GPA and LSAT score were statistically significant. In other words, we can reject the

study is "treatment diffusion," or interaction between treatment and control groups and the sharing of their experiences. However, because students elected their note-taking mode in Constitutional Law I and Evidence by registering on the project site by September 9—very early in the semester—this election would have happened before the treatment and control groups would have meaningfully interacted as second-year students, mitigating any possible threat to internal validity. Moreover, the focus of this study is primarily on the relationship between note-taking mode and academic performance and takes into account the effect the memo may have had on students' choice of note-taking mode. *See infra* notes 48-54 and accompanying text.

56. *See* https://www.lsac.org/jd/lsat/your-score/law-school-performance (last visited October 11, 2017) ("During 2016, validity studies were conducted for 168 law schools. Correlations between LSAT scores and first-year law school grades ranged from .12 to .61 (median is .41)."). Combining LSAT and Undergraduate GPA has more predictive value for law school first-year grade point average, but even then, the median correlation between the combination of LSAT/Undergraduate GPA and 1L GPA for all law schools is only 0.5. *See id.* ("The correlations between UGPA and first-year law school grades ranged from .02 to .50 (median is .27)"). However, correlations between LSAT scores combined with undergraduate grade-point averages and first-year law school grades ranged from .26 to .68 (median is .50)"). The LSAC does not currently publish correlations between LSAT and performance in law school after the first year.

57. *See* https://www.lsac.org/jd/lsat/your-score/law-school-performance (last visited October 11, 2017).

null hypothesis that our results are due to chance, and we would likely see the same results in the population of law students at our law school—not only in the analytic sample.

Table 2 displays the correlations between LSAT and Con Law I/Evidence GPA in the four cohorts.

Table 2. Correlations between LSAT and GPA in Con Law I/Evidence

Cohort	Correlation (Con Law I/Evidence GPA and LSAT)	t-ratio	P value
Memo			
Handwriters	0.44	10.01	<0.0001***
[n=31]			
Laptop Users	0.7	12.87	<0.0001***
[n=27]			
Non-Memo			
Handwriters	0.2	7.5	<0.0001***
[n=15]			
Laptop Users	0.5	14.6	<0.0001***
[n=40]			

*** p<0.01, ** p<0.05, * p<0.1

We also analyzed the correlations according to LSAT quartile for each cohort, with the correlations between LSAT quartile and Con Law I/Evidence GPA being weak on the whole. Out of sixteen combinations (four quartiles for each of the four cohorts), fourteen combinations had correlations between LSAT and Con Law I/Evidence GPA at or below 0.31; LSAT quartile in these fourteen combinations was a weak predictor of the Con Law I/Evidence GPA. In the remaining two combinations, both involving the top LSAT quartile, the correlation was 0.57. The mean differences between the Con Law I/Evidence GPA and LSAT scores by quartile were statistically significant. The detailed correlations according to LSAT quartile are included in Appendix Table 1A.

The fact that the LSAT quartile analysis produced much lower correlations in fourteen of the sixteen combinations than the Table 2 correlations between LSAT scores and Con Law I/Evidence GPA might result from the small size of the quartiles within each cohort, ranging from four to ten students. In addition, our data show that although LSAT overall was positively associated with Con Law I/Evidence GPA, there was significant inconsistency within the LSAT quartiles as to the Con Law I/Evidence GPA.

Because mean LSAT was positively associated with Con Law I/Evidence GPA, we compared the mean difference in the Con Law I/Evidence GPA

of handwriters with laptop users, controlling for mean LSAT score of each group. Handwriters on average outperformed laptop users in their Con Law I/Evidence GPA, regardless of whether the students had received the laptop memo. After taking into account mean LSAT, handwriters in the Memo group had a mean Con Law I/Evidence GPA that was 0.2 higher than laptop users also in the Memo group. On our 4.0 grading scale where, for example, a B is a 3.0, a B- is a 2.67, and a C+ is a 2.33, a mean difference of 0.2 GPA points is a substantial improvement. In other words, handwriting was associated with an increase in Con Law I/Evidence GPA from, for example, 3.00 to 3.20—a meaningful increase. The results for the Memo group were statistically significant. However, the results for the Non-Memo group—which indicated that handwriters experienced a more modest mean Con Law I/Evidence GPA increase (0.08 GPA points) than laptop users—were not statistically significant. The relatively low mean difference between handwriters and laptop users in the Non-Memo group and the lack of statistical significance for the results might be explained by the fact that the Non-Memo group had only fifteen handwriters, falling well short of parity in representation with the forty laptop users who were also in the Non-Memo group.[58] By contrast, the Memo group was far more internally balanced in terms of numbers of students who chose to handwrite notes (thirty-one students) and those who chose to use laptops (twenty-seven students).[59] The mean differences in Con Law I/Evidence GPA between handwriters and laptop users, taking into account mean LSAT, are set forth in Table 3.

Table 3. Comparison of Mean Differences in Con Law I/Evidence GPA of Handwriters vs. Laptop Users, Controlling for LSAT Score

Cohort	Mean Difference in Con Law I/Evidence GPA (HW vs. LU)	t-ratio	P value
Memo	0.2	1.57	0.0607*
Non-Memo	0.08	0.49	0.3150

*** p<0.01, ** p<0.05, * p<0.1

58. *See, e.g.*, Charles H. Brase & Corrinne P. Brase, Understandable Statistics: Concepts And Methods 369 (11th ed. 2015) ("After a great deal of theoretical as well as empirical study, statisticians agree than if *n* is 30 or larger, the sample mean distribution will appear to be normal and the central limit theorem will apply.").

59. In addition, the Memo group was balanced on covariates with the Non-Memo group, given that the means of each group—Memo and Non-Memo—were nearly equal on the basis of their first-year GPA and LSAT, as well as the fact that their first-year GPA was within 0.05 first-year GPA points (as noted in Figure 1A in the Appendix) and that their LSAT was within 0.5 LSAT points.

To provide a more categorical look at the mean differences in GPA, we disaggregated the LSAT mean control by restricting analysis on the basis of LSAT quartile within the Memo and Non-Memo groups. These results are documented in Table 4. Here, too, we compared Con Law I/Evidence GPAs of handwriters with those of laptop users, using a mean-differences approach, and again sorting students into the Memo and Non-Memo groups. Handwriters, whether in the Memo or Non-Memo group, outperformed laptop users in every LSAT quartile. Moreover, in the Memo group, handwriters in the top two LSAT quartiles drastically outperformed laptop users, outgaining laptop users by approximately one grade position (e.g., B to B+). In four of the eight combinations, the results were statistically significant. Although not every quartile of LSAT score was statistically significant, these results as a whole suggest the substantially positive association between handwriting and increases to Con Law I/Evidence GPA.

Table 4. Comparison of Mean Differences in Con Law I/Evidence GPA of Handwriters vs. Laptop Users, by LSAT Quartile

Cohort	Mean Difference in Con Law I/ Evidence GPA (HW vs. LU)	Standard Error (HW vs. LU)	t-ratio	P value
Memo				
1st LSAT quartile	0.31	0.11	2.74	0.0106**
2nd LSAT quartile	0.39	0.05	7.84	<0.0001***
3rd LSAT quartile	0.11	0.06	2.03	0.0303**
4th LSAT quartile	0.005	0.16	0.03	0.516
Non-Memo				
1st LSAT quartile	0.14	0.14	1.01	0.177
2nd LSAT quartile	0.27	0.06	4.22	0.0021**
3rd LSAT quartile	0.1	0.09	1.15	0.1532
4th LSAT quartile	0.18	0.23	0.79	0.76

*** p<0.01, ** p<0.05, * p<0.1

As a final confirmation of our correlation results and mean-differences findings, we tested the assumptions on which the analyses producing the results reported in Tables 3 and 4 rely—that handwriters outperform their laptop-user peers—while also testing the effect of the laptop memo on student performance. To do this, we performed a difference-in-differences analysis—a quasi-experimental method that exploits the panel structure of the data to

estimate the effect of an intervention while at the same time providing precise associational estimates of covariates.[60] This method is primarily used to compare two groups—a treatment group (students who received the memo) with a control group (students who did not receive the memo)— to calculate the effect of treatment. Thus, difference-in-differences analysis estimates the effect of a treatment, such as receiving the laptop memorandum, on a dependent variable, such as academic performance. We employed this analysis to remove the possibility that receiving the memorandum may have contributed to the estimates of the increase in academic performance attributable to handwriting in our associational analysis.[61]

60. *See, e.g.*, Joshua D. Angrist & Jorn-Steffen Pischke, Mostly Harmless Econometrics: An Empiricist's Companion, 227-43 (2008); David Card & Alan B. Kreuger, *Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania*, 84 Am. Econ. Rev. 772, 772-93 (1994). While we report the results of this method in terms of the effect of the memo on Con Law I/Evidence GPA, we do not employ this methodology merely for its causal properties—that is, to find the effect of treatment. Instead, we use it to provide more precise estimates of the relationship between handwriting and 2L GPA, which is the focus of this study.
We should also note that we have established baseline equivalence between the Memo and Non-Memo groups on the basis of two important variables: LSAT scores and 1L GPAs (this latter relationship is graphed and included in the Appendix as Figure 1A). In fact, both Memo and Non-Memo groups had nearly equivalent average 1L GPAs—approximately 2.90. Given that the two groups started their 2L year with substantially the same 1L GPA, we would expect their trend lines to roughly follow one another's trajectory or, in other words, exhibit parallel trends.
Our difference-in-differences analysis has only two time periods. Thus, it is important to note this baseline equivalence on the dependent variable of interest, because with a two-observation panel—pre-treatment and post-treatment—the parallel-trends assumption that applies to a generalized difference-in-differences analysis cannot be graphically demonstrated, as it is the counterfactual that cannot be observed. However, this evidence of baseline equivalence gives an inference that the parallel-trends assumption likely would be met with more observations in the data panel. *See, e.g.*, Institute for Policy Research, *Difference in Difference Materials from Day 4 of the Annual Workshop in Quasi-Experimental Design and Analysis*, Northwestern Univ. (2015), https://www.ipr.northwestern.edu/workshops/annual-summer-workshops/quasi-experimental-design-andanalysis/2015/2015%20QE%20workshop%20materials/Day%204.2.pdf.

61. The results from the difference-in-differences analysis indicate that the Memo students improved their Con Law I/Evidence GPA by 0.173 GPA points over the Non-Memo students, but not at a statistically significant level. This result is not surprising, because it is doubtful that having received the laptop memo alone would result in such a large increase (0.173 GPA points) in Con Law I/Evidence GPA. It is more likely that having received the memo—when combined with other factors omitted from this analysis that may be confounded with the treatment of having received the memo—could be associated with an improved Con Law I/Evidence GPA compared with that of those who did not receive the memo.
To that end, when using a binary variable for handwriting as a dependent variable and a logistic difference-in-differences specification, with receipt of the memo as the treatment and LSAT as a control, students who received the memo had a 0.42 lower probability than their peers who did not receive the memo of handwriting their notes in their second-year courses. This fact may be depressing the significance of the effect of the memo observed in the difference-in-differences analysis discussed in Table 5.
As with the West Point, UC Irvine, and Patterson classroom studies, we did not control

In our study, the difference-in-differences methodology measured the difference in Con Law I/Evidence GPAs between the Memo and Non-Memo groups, taking into account the difference that existed between these groups on the basis of their 1L GPA.[62] The distance between their 1L GPAs is subtracted from the resulting difference of the Con Law I/Evidence GPAs for the two groups, creating a measure of the effect of treatment (having received the memo). Although this analysis may seem tangential to our study, it is helpful to isolate the effect of receiving the memo to get a more precise estimate of the relationship between handwriting and Con Law I/Evidence GPA. In performing this analysis, we removed from the sample the three students who received the laptop memo for the first time in the fall 2016 Remedies course. We removed those students from the analysis because difference-in-differences methodology requires random assignment, which would have been violated by including the students who chose to take the Remedies course.

Our difference-in-differences analysis yielded an important confirmation of the associational findings from our earlier analyses: Handwriting class notes resulted in improved academic performance, corresponding with a 0.166 GPA point increase—half a grade increment—in Con Law I/Evidence GPA at a statistically significant level. This effect size is very similar to the effect we observed when comparing mean differences between handwriters and laptop users among the Memo group, illustrated in Table 3. In that associational analysis, among students who received the memo, we observed a 0.20 GPA point increase in Con Law I/Evidence GPA associated with handwriting.[63]

for an "instructional variable"—i.e., whether the experience of having been in Murphy's Civil Procedure course (which is collinear with the treatment of receiving the memo) compared with having been in the other Civil Procedure course (which is collinear with not having received the memo) may have affected subsequent performance in the Con Law I and Evidence courses. Even without controlling for an instructional variable, the resulting difference in GPA between the students who received the memorandum and the students who did not serves to aid in isolating the effect of the memo on Con Law I/Evidence GPA, thereby proffering a more precise estimate of the relationship between handwriting class notes and Con Law I/Evidence GPA.

62. Of the 119 second-year law students who responded to the questionnaire in fall 2016 about their note-taking mode in Constitutional Law I and in Evidence, the correlation between mean 1L GPA and the combined weighted GPA for Constitutional I and Evidence was 0.74. The correlation was statistically significant, with alpha levels at 0.0001. In light of our findings in this article, it is quite possible that students' note-taking mode in the 1L courses could have been associated with their 1L GPA.

63. The association between handwriting notes and Con Law I/Evidence GPA for the Non-Memo group, as reported in Table 3, was considerably lower—0.08 GPA points—than our difference-in-differences analysis estimate. However, it should be noted that the mean differences analysis reported in Table 3 disaggregated students into Memo and Non-Memo groups, while our difference-in-differences analysis was performed on the aggregated analytic sample, without distinctions. Also, the mean difference in Table 3 between handwriters and laptop users in the Non-Memo Group was not statistically significant. As such, we are not concerned with the ostensible disparity between the estimate from our difference-in-differences analysis and the mean differences analysis for the Non-Memo group.

Our difference-in-differences estimate of a 0.166 GPA point increase is even more precise than our associational findings, because it not only accounts for LSAT differences among students but also removes the potential bias of receiving the memo. The consistency between the findings of our associational and difference-in-differences analyses evidences a substantial likelihood that handwriting class notes yields a significant increase in academic performance. Our results are reported below in Table 5.

Table 5. Difference-in-Differences Analysis Using Con Law I/Evidence GPA as the Dependent Variable

Variables	**Difference-in-Differences Model Estimates**
Baseline Differences (Memo vs. Non-Memo)	-0.2109*
	(0.1181)
Time Period (Mean Change for Non-Memo)	-0.0323
	(0.0883)
Difference-in-Differences Effect	0.1731
	(0.1335)
LSAT Score	0.0474***
	(0.0059)
Handwriting	0.1664**
	(0.0832)
Constant	-4.147***
	(0.8808)
Observations	226

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

V. Conclusion

Our study of whether academic performance in two required doctrinal law school courses was linked to note-taking mode found that, when controlling separately for LSAT, handwriters had a higher combined GPA in those courses than laptop users. Moreover, our results, using a quasi-experimental method (the difference-in-differences analysis) to control for LSAT and to isolate the effect of receiving a memo about the pitfalls of using a laptop to take notes, indicated a substantial positive association at a statistically significant level between handwriting and academic performance.

We chose to analyze handwriters' versus laptop users' academic performance in the fall semester of the second year of law school because we wanted our entire study population to have had the same required curriculum previously.

However, because 1L GPA may be highly predictive of subsequent academic performance in law school,[64] different comparisons in the future would help to establish not only the effect of note-taking modes on academic performance but also the repercussions of letting students know about the effects found by other researchers connecting handwriting to positive academic performance.

Our findings that second-year law students who handwrote their notes outperformed laptop users is consistent with the results of studies in other higher education settings. This study meaningfully contributes to the ongoing discussion about whether computer usage in the higher education classroom might be hindering academic performance and, in particular, performance on essay exams requiring conceptual applications. Future studies on note-taking mode and academic performance in the law school setting, with larger sample sizes covering multiple semesters, would be illuminating—not only to test the generalizability of our results, but to challenge the trend of student laptop use in the law school classroom.

Appendix

Table 1A: Correlations Between Constitutional Law I/Evidence GPA and LSAT Scores by LSAT Quartile

Cohort	Correlation between LSAT and Con Law I/ Evidence GPA	t-ratio	P value
Memo/HW			
1st LSAT quartile	0.57	3.57	0.0117*
2nd LSAT quartile	0.31	8.0	<0.0001***
3rd LSAT quartile	-0.12	6.4	0.0002***
4th LSAT quartile	0.05	5.3	<0.0005***
Memo/LU			
1st LSAT quartile	0.17	5.22	0.0017***
2nd LSAT quartile	0.26	7.55	0.0003***
3rd LSAT quartile	-0.3	3.2	0.0108**
4th LSAT quartile	0.3	10.3	<0.001***
Non-Memo/LU			
1st LSAT quartile	0.57	6.5	<0.0001***
2nd LSAT quartile	0.2	10.12	<0.0001***
3rd LSAT quartile	0.22	8.24	<0.0001***
4th LSAT quartile	0.14	7.7	<0.0001***
Non-Memo/HW			
1st LSAT quartile	-0.4	2.36	0.0494**
2nd LSAT quartile	-0.8	3.2	0.0245**
3rd LSAT quartile	0.16	8.25	0.0019***
4th LSAT quartile	-0.1	25.6	<0.0001***

*** p<0.01, ** p<0.05, * p<0.1

64. *See, e.g.*, *supra* note 56.

Figure 1A: Baseline Equivalence between Memo and Non-Memo Groups on Cumulative GPA