Teaching The Digital Caveman: Rethinking The Use Of Classroom Technology In Law School

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New forms of media have always led to a "moral panic" that technology is changing the way people think. Educators see the influence of new technologies on popular culture and worry that if they do not quickly embrace them as well, they will seem out of date, and their students will get left behind. Initially, however, no research exists on the classroom effectiveness of these technologies, so educators rely instead on intuition to guide their choices. But the track record for making decisions in this way is fraught with mistaken assumptions and failed experiments.

Seeing all this through the more objective lens of "learning science," however, shows that the way we think and learn has not changed much in 50,000 years. Thus, a more accurate

claimed by Pressey and others); see also BURHAN STUDY, infra note 228, at 20. Another mistaken assumption about today's students is that they are all tech savvy. See infra p. 252 and accompanying notes.

6 Steven Pinker, Opinion, Mind Over Mass Media, N.Y. TIMES, at A3 (June 10, 2010), http://www.nytimes.com/2010/06/10/opinion/10pink.html [http://perma.cc/7KM-ZN6R] [hereinafter Pinker, Mind Over Mass Media]; see WILLIAM POWERS, HAMILTONE'S BLACKBERRY 394-97 (2010) (early 1990s characterized by widespread fear that mass media was turning the public into "helpless automatons"); MARIE-FRANCOISE WOLF, FROGHT AND THE SQUIRREL: THE STORY AND SCIENCE OF THE BRAIN (2007) (fearlessly worried transition from oral to written culture threatened society); Vaughan Bell, Don't Touch That Dial: A History of Media Technology Sources, From The Printing Press to Facebook, SMTH (Feb. 15, 2010), 7:00 AM, http://www.smth.com/article/health_and_sciences/science/20100215/dont_touch_that_dial.html [http://perma.cc/KAB-3454] (in the 1980s, when worried radio was having a deleterious effect on learning by dividing students' attention between the "humdrum preparation of school assignments and the compelling excitement of the loudspeaker"); see also NICHOLAS A. CHRISTakis, There Is No New Self, or Is The INTERNET Changing The Way YOU Think?, supra note 3, at 203, 203 (the Internet is not different than equally monumental brain-enhancing technologies like books and telephones, yet it is doubtful they changed the way we think either); Mihaly Csikszentmihalyi, I Must confess to Being Puzzled, or Is The INTERNET Changing The Way You Think?, supra note 3, at 374, 374 (preeminent professor of psychology says no evidence the printing press changed the way we think much less the Internet); Carissa Young, With Great Power Comes Great Responsibility?, AMERICAN COMIC BOOK CENSORSHIP 1, 5 (2001) (1960s saw widespread fear comic books harmed student learning).

7 See BENEDICT CAREY, HOW WE LEARN 213 (2014) (most of our instincts about learning are misplaced, incomplete, and flat wrong); STANBURY BERGEL, READING IN THE BRAIN: THE SCIENCE AND EVOLUTION OF A HUMAN INVENTION 272 (2009) (educational decisions are often grounded in well-meaning intuitions that turn out to be wrong resulting in misguided teaching practices); John Palfrey, Storier, Law School Casebooks, on LEGAL EDUCATION IN THE DIGITAL AGE 106, 122-23 (Edward贝壳 ed., 2010) (law professors need to incorporate research from other fields to inform their teaching instead of relying on observable student behavior); infra p. 251 and accompanying notes.

8 See infra Part I.

9 Roger Schank, The Thinking Process Hasn't Changed in 5000 Years, EDCS, https://edcs.org/responsive-detail/01519 [https://perma.cc/SM5V-HEV7] [hereinafter Schank, The Thinking Process] (Professor Schank, one of world's leading scholars on artificial intelligence, learning theory, cognitive science, and virtual learning environments, says "the Internet has not changed the way [we] think", only the way we gather information has changed); see HANK DAVIS, CAYMEN LOGIC: THE PERSISTENCE OF PRIMITIVE
picture of how today’s law students really learn is suggested by the title in that they use digital tools to gather information, but still process it into knowledge using the original factory equipment of our caveman ancestors.10

Thinking in a Modern World 23-34 (2009); Roger Schank, Everyone is an Expert, in IS THE INTERNET CHANGING THE WAY YOU THINK?: supra note 3, at 365, 365 (hereinafter Schank, Everyone is an Expert) (the Internet is not changing the way anyone thinks; that has not changed since cavemen days); Pinker, Mind Over Mass Media, supra note 5 (instrumental factors like technology do not rewrite the basic information processing capacities of the brain); Matt Richtel, Technology Changing How Students Learn, Teachers Say, N.Y. TIMES, at A18 (Nov. 1, 2012), http://www.nytimes.com/2012/11/02/education/technology-is-changing-how-students-learn-teachers-say.html?_r=0; http://www.scienceofsociallearning.com/ReinforcementTheory.html; [hereinafter Richtel, Technology Changing How Students Learn, Teachers Say]) technology may be changing student learning behaviors but not long-term studies support the claim that it is changing attention spans); Daniel T. Willingham, Opinions, Smartphones Don’t Make Us Dumber, N.Y. TIMES, at A52 (Jan. 21, 2015), http://www.nytimes.com/2015/01/21/opinion/smartphones-dont-make-us-dumber.html [http://www.nytimes.com/2015/01/21/opinion/smartphones-dont-make-us-dumber.html]; supra note 10; http://www.pinkerblog.com/2015/02/03/destiny/; [hereinafter Pinker]; Brown, supra note 10; infra pp. 387-89 and accompanying notes. But see abban J. B. Bussanici et al., Dormancy in Mice: New Opportunities for Evolutionary Psychology, 9 PLOS BIOLOG 1, 1-9 (2011); http://www.pnasblog.org/article/fetchObject.action?artid=info:doi/10.1073/pnas.1516401113; infra pp. 387-89 and accompanying notes. But see abban J. B. Bussanici et al., Dormancy in Mice: New Opportunities for Evolutionary Psychology, 9 PLOS BIOLOG 1, 1-9 (2011); http://www.pnasblog.org/article/fetchObject.action?artid=info:doi/10.1073/pnas.1516401113; prior research on cognitive trends shows that evolution stopped 50,000 years ago and that man-made cognitive changes including advances in agriculture, domestication of animals, etc. have resulted in genetic, evolutionary changes within the last 10,000 years; it is possible some could occur in as few as twenty-five generations.

As a preliminary matter, it is important to define what is meant by “thinking.” From a phenomenological perspective, nearly all environmental influences can “change” our perceptions and the content of our thoughts. The point we seek to make here is one that is often missed: even from the color of the chalkboard to the pictures hanging on the wall may arguably affect the way students think and learn. For example, Cassady, Can It Be Learned? supra note 3, at 426-27, 526-27 (2014); supra note 9. (2012); supra note 4. (2014) (study found that placing a photo of Bill Clinton in a classroom caused males to speak longer than females; replacing it with a photo of Hillary Clinton eliminated gender differences in speaking length).

However, this Article is responding to the claim that digital technologies have changed the way our students process and use information. Yet for there is no evidence to support that assertion. See Mark Papol, Brain, Candy & Bad Mathematics, in IS THE INTERNET CHANGING THE WAY YOU THINK?: supra note 3, at 70, 70 (professor of evolutionary biology says we know the Internet has not changed the brain because we can speak to people who do not Internet access and think the same as we do). Steven Pinker, Not of All, in IS THE INTERNET CHANGING THE WAY YOU THINK?: supra note 3, at 87, 87 (it is “courageous” to believe that digital technology has changed the way scientists think compared to a decade ago); supra note 4, at 365, supra note 10 (“extraordinary claims require extraordinary evidence”); Gregory Paul, Jill F. Y. TENG, IS THE INTERNET CHANGING THE WAY YOU THINK?: supra note 3, at 129, 129 (the only way to know if the Internet is changing the way we think and learn is to run a controlled experiment to test this hypothesis). The experts tell us it is unlikely the brain is even capable of the changes suggested by those who claim the existence of a so-called cognitive divide. See infra pp. 207-08.

10 Steven Pinker, HOW THE MIND WORKS 343 (1997) (hereinafter Pinker, How the Mind Works)
suggests strategies for using, and knowing when not to use, popular classroom technologies like laptops and PowerPoint in ways that promote the critical thinking skills we want our students to develop. Part IV concludes by recommending that we reject popular stereotypes and clichés about how best to teach digital native students, and instead employ a hybrid approach to classroom technology that blends traditional tools with new, digital ones in ways that better match our methods with the learning outcomes we seek.

I. "IT'S DéJÀ VU ALL OVER AGAIN": A BRIEF HISTORY OF MODERN CLASSROOM TECHNOLOGY

Teaching has always depended on effectively communicating information and ideas to students. As electronic technologies began to proliferate in the early twentieth century, educators naturally looked for ways to adapt them to the classroom. This led to a series of educational experiments over the past hundred years involving the paradigm shifting technologies of their day, including film, radio, television, and early desktop computers. Each promised to "revolutionize" the way students learn. In some cases, these experiments were preceded by an "academic moral panic," much like the one today in that educators believed students raised on new forms of media had developed unique learning styles, which meant teaching methods also had to change to accommodate this new way of thinking.

processes involved in learning; the neurological changes that occur, and the evolutionary circumstances that explain why human cognition is constrained in the ways that it is. Reflecting this synergy, a new field has emerged in recent years called "Evolutionary Cognitive Neuroscience" that incorporates all these disciplines. Austin Frill et al., Where Evolutionary Psychology Meets Cognitive Neuroscience: A Precise & Evolutionary Cognitive Neuroscience, 5 EVOLUTIONARY PSYCH. 525, 535 (2007); see FUNK, HOW THE MIND WORKS, supra note 10, at 343, 355 (to fully succeed as teachers, it is critical to understand not only how the brain works, but also what it was originally designed to do); ROGER SCHANK, TEACHING MINDS: HOW COGNITIVE SCIENCE CAN SAVE OUR SCHOOLS, at xv, xvi, 13, 18 (2011) [hereinafter SCHANK, TEACHING MINDS] (educators need to understand how the brain works); Palfrey, supra note 7, at 122-23 (few professors need to incorporate research from other fields to better inform their teaching).


LARRY CUBAN, TEACHERS AND MACHINES: THE CLASSROOM USE OF TECHNOLOGY SINCE 1920, at 3, 19, 77, 78-79 (1965) [hereinafter CUBAN, TEACHERS AND MACHINES]; ANDREW WATTERS, THE MEMORIALS OF EDUCATION TECHNOLOGY 25-29 (2014) (detailing that early classroom computer technology used in the 1980s included many features of today’s countertops such as message boards, that e-mails, instant messaging, multiple gardens and shared access).


Bennett et al., supra note 3, at 782 ("moral panic" refers to a form of public discourse, often initiated by the media using sensationalist, dramatic language, in which a particular group in society, like digital natives, is portrayed as radically different and posing a threat to the status quo); see Bennett & Maton, supra note 3, at 328 (educators believed in the 1950s and 1960s that students raised on television and popular music were "radically different" than their predecessors, leading schools to change the way students were taught); Bell, supra note 6 (educators in the 1960s were concerned that radio was destroying students’ ability to pay attention and do their homework); supra p. 243; supra note 6.

In CuBaN, Teachers And Machines, supra note 16, at 11, see TECaD OPENHUISER, The Flackering Mind: Saving Education from theFalse Promise of Technology 3 (2004) (Eisenstein said, "In two years textbooks as the principle medium of teaching will be as obsolete as the horse and carriage are now... There is no limitation to what the camera can do").

See supra Section III.C.

MoOC stands for "Massive Open Online Course." See CuBaN, Teachers And Machines, supra note 16, at 19; Robert A. Reiser, A History of Instructional Design and Technology: Part I: A History of Instructional Media, 49 EDUC. TECH. RES. & DEV. 55, 56 (2001) (a spokesman for the National Educational Association said in 1932 that "film and radio will be as common as the book and powerful in their effect on learning and teaching").

See CuBaN, Teachers And Machines, supra note 16, at 42; Bennett & Maton, supra note 3, at 328 (educators in the 1950s and 1960s believed that children immersed in a culture of television and popular music had developed fundamentally different learning needs); see also supra p. 243; supra note 6.

See CuBaN, Teachers And Machines, supra note 16, at 17, 25-26, 33, 38, 109; CuBaN, Overload And Underload, supra note 17, at 133, 138, 196; OpEnHUISER, supra note 19, at 5 (the proliferation of classroom film and TV equipment in the 1960s and 1970s far outpaced student achievement); John Palfrey & Urs Gasser, Born Digital: Understanding the First Generation of Digital Natives 50 (2006) (television did not transform education and neither will the Internet); Reiser, supra note
like a sure thing at the time since film was likely perceived to be just as revolutionary back then as the Internet is today. Yet more than one hundred years later and after several attempts to replace textbooks with "visual" technologies, books remain the most popular and effective classroom technology we have. Education-by-radio must have also seemed like a surefire way to use new technology to bring the world’s best teachers to underserved classrooms, yet it failed as well. Perhaps that makes it less surprising that only a few years after the first MOOCs launched, Silicon Valley entrepreneur Sebastian Thrun, widely considered the "Godfather" of this technology, conceded that his "overhyped" invention was also a failure. In his words, MOOCs do not work because they are a "lousy" product that cannot substitute for the individualized, face-to-face attention most students need to learn.

One educational technology historian notes that many of the "overhyped and overvalued" classroom technologies being marketed today are, like MOOCs, the same recycled ideas that already failed at least once before during the

21. at 58 (by the mid-1980s, much of the interest in instructional television was over).

Regarding fears that technology is changing the way students think and learn, requiring a corresponding change in the way we teach, see WATTERS, supra note 5, at 210 (conceding that notes reading pedagogy has not changed much since the ancient Sumerians invented reading and writing because "important teaching principles are "as old as written language itself"); Christakis, supra note 5, at 203; Cookmen and Hackley, supra note 5, at 274; see also DIEBAM STUDY, supra note 228, at 20 (based on meta-analysis of thousands of independent studies from around the world researchers found no evidence that the Internet has changed the way students learn); see also supra p. 240, supra note 5, infra pp. 268-69 and accompanying notes.

22. Palley, supra note 7, at 169 (textbooks are still used at Harvard Law School because they are an effective way to communicate information to students); see infra Section II.D.


24. WATTERS, supra note 16, at 35. Carmel DeAmicis, A Q&A with “Godfather of MOOCs” Sebastian Thrun After He Discarded His godchild, VOXICO (May 12, 2014), http://www.voxico.com/20140512/a-qa-with-godfather-of-moocs-sebastian-thrun-after-he-discarded-his-godchild [http://perma.cc/745Q-GX77] (Thrun disowned MOOCs saying, "We're just educating people as others washed, or as I wished. We have a lousy product"); see also Randy Best, How MOOCs Helped or Hurt, INSIDE HIGHER ED (Jan. 5, 2010), https://www.insidehighered.com/views/20100105/20100105-sep-moocs-helped-and-hurt-debates-about-future-higher-education [http://perma.cc/8D6E-UWKM]. A 2014 study by the University of Pennsylvania Graduate School of Education found that only 4% of students who registered for MOOCs completed them. One of the reasons preferred for why MOOCs have such an abysmal retention rate is that many see free of charge; presumably, courses that students must pay to attend have better satisfaction rates.

25. DeAmicis, supra note 24; see Rebecca Schuman, The King of MOOCs Abandons the Thrive, SEATTLE TIMES (Dec. 10, 2013), http://seattletimes.nwsource.com/html/localnews/2030272631_thriveabandons.html (with respect to secondary school education, more than 30 years after computers were first placed in classrooms, they are new commonplace; yet teaching practices and learning outcomes still look the same).

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27. 28. See WATTERS, supra note 16, at 15. Some of the educational technology products introduced during the first Dot Com boom like AllLearn and Fathoms were backed by a consortium of the nation’s most elite universities. Id. Ms. Watters speculates that perhaps they are not remembered today because of the shame associated with their failure. Id. at 17-18.

29. Bennett & Martin, supra note 3, at 338; see WATTERS, supra note 16, at 24; Lawrence A. Cunningham, Digital Education in Law School Course Books, in LEGAL EDUCATION IN THE DIGITAL AGE 85, 99-96, 100 (Edward Rubin ed., 2012) ("[t]he cost changes, plus I don’t have to buy books" [sic]; several contemporary trends in law school pedagogy like "skills training" and "storytelling" are merely recycled ideas from past).

30. See CUBAN, OVERLOOKED AND UNDERUSED, supra note 17, at 197, 127, 137-39; CUBAN, TEACHERS AND MACHINES, supra note 16, passim.


32. See CUBAN, OVERLOOKED AND UNDERUSED, supra note 17, at 137, 171, 195.

33. CUBAN, TEACHERS AND MACHINES, supra note 16, at 50, 63-65, 109; see CUBAN, OVERLOOKED AND UNDERUSED, supra note 17, at 27, 37 (educators inflate the adoption of new teaching tools with new ideas when in fact new technologies are most often used "to do the same old stuff"); Cunningham, supra note 29, at 100 (with respect to innovations in legal education, "plus is change, plus it’s not the same choice" [sic]; note New, Professors Say Technology Helps in Litigation, Not Learning, CHRONI, HIGHER ED. (Jun. 28, 2013), http://chronicle.com/blogviews/dcampus/ professors-say-technology-helps-in-litigation-rather-than-in-learning/41777/ [http://perma.cc/ 2RE7-KM3J] (classroom technology mostly used as a management tool; little to no indication it is used for truly innovative pedagogy); see also Neil Entmacher, New Interest, Old Rhettics, Limited Results, and the Need for a New Direction for Computer-Mediated Learning, NAT’L, EDUC. POL’Y CTR., U. COLO. BOULDER (Nov. 14, 2014), http://nepc.colorado.edu/publications/personalized-instruction/ (with respect to secondary school education, more than 30 years after computers were first placed in classrooms, they are new commonplace; yet teaching practices and learning outcomes still look the same).
Professor Cuban has identified several reasons why these patterns persist. A few may no longer apply due to differences between today’s digital technologies and the analog ones he studied many years ago regarding their ease of use and flexibility. On the other hand, his conclusion that classroom technology has been historically underserved because administrators hastily invest in it without first consulting teachers still holds true today. For instance, Professor John Palfrey describes how administrators at Harvard Law School did exactly that in the 1990s when, like many other law school administrators at the time, they unilaterally decided to put Internet connections in every classroom. Once the faculty figured out students were using the Internet during class to surf the web instead of learn, they ordered the connections removed.

Administrators feel a great sense of urgency to adopt new technologies because of the public perception that if a school is not doing so, it is falling behind. New technology also generates its own hype, which creates even more pressure to adopt it now and ask questions later. Professor Cuban observes that high

36 See Cuban, Teachers and Machines, supra note 16, at 104; Wattles, supra note 16, at 16–22 (even the use of classroom computers today reflect the same patterns associated with earlier experiments in the 1990s with a platform called PLATO and again during the first Dot Com boom with AllLearn and Pathone).

As Professor Cuban recently acknowledged on his blog that digital technologies are now much more widely adopted and used more frequently than the analog technologies he has studied in the past, Larry Cuban, Using Technology to Nail Down What We Know and Don’t Know About Effects of High-Tech on People Today, LARRY CUBAN ON SCH. REFORM & CLASSROOM PRACT. (Jan. 27, 2014), 1:02 AM, https://larrycuban.wordpress.com/2014/01/27/using-technology-to-nail-down-what-we-know-and-dont-know-about-effects-of-high-tech-on-people/ (last visited Jan. 27, 2014), (hereafter Cuban, Using Technology to Nail Down What We Know). In all other respects, however, Professor Cuban asserts that his original conclusions still hold.

37 See Cuban, Teachers and Machines, supra note 16, at 18, 82–83. But see Simon Cantic, Inclusion Technology Malls into the Law School Curriculum, 42 CAP. U. L. REV. 663, 676 (2014) (noting that legal education reject digital technology because they have difficulty using them, and due to issues with reliability, amongst other reasons).

38 See Cuban, Overheld and Underheld, supra note 17, at 137, 185; Palfrey & Garshe, supra note 23, at 238; Cuban, Teachers and Machines, supra note 16, at 56.


40 Id.; Palfrey, supra note 7, at 167–68.


43 Tech carries great symbolism in the public’s mind and, like high fashion, “conveys a whiff of superiority” compared to schools that do not have it. By investing in new technology, a school creates the perception of innovative teaching because the public easily conflates the two. In practice, however, Professor Cuban finds that technology, with rare exceptions, is used in ways that maintain conventional teaching practices rather than change them.

44 Pressure to innovate means that administrators invest in new technology before a need is identified or teachers have even had a chance to figure out whether or how to use it. Thus, technology often becomes a solution in search of a problem, which further explains Professor Cuban’s paradoxical conclusion that it is “oversold” yet “underused.”

45 Of course, whenever a new classroom technology is first introduced, no research yet exists on its effectiveness or whether it is even compatible with the way students learn. But because educators feel so much pressure to show they are keeping up with the times, they are either unable or unwilling to wait for that research to be done, so they forge ahead anyway based on intuition and “common sense.”

46 Once the technology is paid for and in place, confirmation bias helps validate belief in the correctness of the original Wired (May 8, 2015, 7:00 AM), http://www.wired.com/2015/05/los-angeles-editors/ (http://www.zm 가) 2016, supra note 17, at 158–59, Cuban, Dean Online Instruction Work-3, supra note 59.

47 See Cuban, Overheld and Underheld, supra note 17, at 158–59; Wattles, supra note 16, at 6, 21, 27; Palfrey, supra note 7, at 108 (mentioning money on technology helps a law school burnish its reputation, even if the hardwears sit unused while the faculty figures out what to do with it); Cuban, Dean Online Instruction Work-3, supra note 39.

48 See Cuban, Overheld and Underheld, supra note 17, at 134, 156, 170, 196; Cuban, supra note 33.

49 See Cuban, Dean Online Instruction Work-2, supra note 39; Palfrey & Garshe, supra note 23, at 238 (law schools at every level have done what Harvard did in the late 1990s, which is to spend thousands of dollars on new classroom technologies that remain unused while the faculty decides what to do with them).

50 Id.; Cuban, The Lack of Evidence-Based Practice-2, supra note 38 (in the absence of research, educators adopt new technology because of the high value the public places on it, pressure to appear current, and the fear of negative perceptions if they don’t); see also D’Hanis, supra note 7, at 337 (educational decisions are often grounded in well-meaning ideologies but in the absence of rational thought, these intuitive judgments become largely misplaced teaching practices).
decision since educators see with their own eyes how technology is influencing the lives of those around them and the culture at large. So what began as assumption and intuition is soon treated by all as fact. And the more these assumptions are repeated, their credibility is underestimated even due to a phenomenon called the "illusion of truth." This further discourages skepticism and critical review of the underlying beliefs which allows them to proliferate even more.

Professor Maton describes a "certainty-complacency spiral" among scholars in which stereotypes about digital natives circulate in the literature without challenge. The only support these authors provide are references to other authors making the same unsubstantiated claims. For example, the assertion that all digital natives are tech savvy is widely accepted as true, even though the data says otherwise.

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24 Bennett et al., supra note 3, at 779 (though many claims about digital native appeal to common sense, they lack empirical support); Cuban, Does Online Instruction Work? supra note 39, at 4; Daniel Willingham, Why Don't Students Like School? A COGNITIVE SCIENTIST ANSWERS QUESTIONS ABOUT HOW THE MIND WORKS AND WHAT IT MEANS FOR YOUR CLASSROOM, 121 (2005) (hereafter Willingham, Why Don't Students Like School?) (confirmation bias turns the intuitive beliefs educators hold about how students learn into firmly-held views).

25 Bennett & Maton, supra note 3, at 328; see DEHAES, supra note 7, at 327 (intuition should not replace carefully accumulated scientific knowledge); ROBERT SCHWARTZ, A CELEBRATION OF MYNDNESS: AN EDUCATOR'S GUIDE TO THE HUMAN BRAIN 54 (1999) (intuition about how students learn leads to mistakes, overgeneralizations, and stereotyping).

26 See Haun, supra note 3, at 285 (the "illusion of truth" effect in a well-documented psychological phenomenon in which people conflate the frequency with which a statement is repeated with its veracity); Lynn Hasher et al., Frequency and the Conference of Relevancy Validity, 16 J. VERNAL LEARNING & VERBAL REMNANT. 107, 111 (1977) (studies show that merely repeating a statement over and over increases the listener's belief in its truth); Deann Deaz, The Illusion of Truth, FRB/TIM 6 (Dec. 8, 2010), http://www.spring. org.uk/2010/12/the-illusion-of-truth.php (http://perma.cc/47H7-8F7U) (one of the simplest, most effective persuasive techniques is to keep repeating a statement because the brain equates familiarity with truth).

27 Bennett et al., supra note 3, at 783; see also Cuban, Does Online Instruction Work?, supra note 39.

28 Bennett & Maton, supra note 3, at 328.

29 Id.

30 Educators incorrectly assume digital natives are tech savvy because they confute fluency with proficiency. See supra note 16, at 60; see also supra Section II.A.2. Find many digital natives knowledgeable about Web 2.0 tools, do not create content, do little gaming, and instead use the Internet mostly for social activity. Jones & Blau, supra note 4, at 34; Li & Hong, supra note 1, at 728 (no difference between digital native and immigrant in their use of technology). Penny Thompson, The Digital Natives as Learners: Technology Use Patterns and Approaches to Learning, 65 COMPUTER & EDUC. 12, 20, 23 (2012) (surveys show college students have limited proficiency with a small number of devices that get used for a narrow range of activities and not very well). Weng et al., An Investigation of Middle School Science Teachers and Students' Use of Technology Inside and Outside of Classrooms: Considering Whether Digital Natives are More Technology Savvy than Their Teachers, 62 EDUC. TECH. RES. & DEV. 677, 643, 655

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It is only later, when classroom technology fails to work as promised, or the unintended consequences come to light, that some may question the wisdom of the original decision. It has been happening for years in legal education with the backlash against classroom laptops that were first touted as necessary to accommodate the new, "multitasking learning style" of digital natives. It is consistent with, and indeed predicted by, Professor Cuban's work, as he finds that teachers typically stop using a new technology once the initial hype subsides and they realize that a supposedly "revolutionary" tool is actually less effective than the one it replaced. At the classroom level, Professor Cuban finds that historical patterns show teachers are generally pragmatic; they adopt new technology when it helps solve a problem not addressed by existing solutions. Otherwise they tend to stick with what is already working, which is why they are frequently criticized for being resistant to change and stuck in the past. Teachers also have a track record of rejecting new technology when they believe it will interfere with student classroom rapport, a concern expressed by some law professors about digital technologies as well. On the other hand, they routinely embrace it if they think it will help them motivate students to learn. And though a study of more than 1000 New York and Utah high school students finds they are no more tech savvy than their teachers, Megan O'Neil, Confronting the Myth of the Digital Natives, CRN. HIGHER EDUC. (Apr. 21, 2014), http://thetimesunion.com/article/Confronting-the-Myth-of-the-154969 (http://perma.cc/S0LS-CN3E) (observing that the assumption today's students are tech savvy is a myth).

31 See Cuban, OVERBILT AND UNDERBILT, supra note 17, at 132-33.

32 See Paul L. Carron & Rafael Caly, Taking Back the Law School Classroom: Using Technology to Foster Active Student Learning, 54 J. LEGAL EDUC. 551, 550-58 (2004) (listing criticisms by law professors of the "unmitigated use" of PowerPoint and laptops because of their negative effect on learning); Eric A. Deffitt, The Dynamics of the Contemporary Law School Classroom: Looking at Laptops Through a Learning Style Lens, 39 DAYTON L. REV. 201, 208-10 (2014) (identifying backlash by law professors against classroom laptops); Maxwell, infra note 60, at 5; Palfrey, supra note 7, at 107-08.

33 See Cuban, TEACHING IN A DIGITAL AGE, supra note 16, at 54; Palfrey, supra note 7, at 107 (when it comes to the use of classroom technology in law school, we tend to lurk ahead into the future, retreating and then, perhaps, advance again).

34 See Cuban, OVERBILD AND UNDERBILD, supra note 17, at 167-68; Cuban, TEACHING AND MACHINES, supra note 16, at 35; see also WILLINGHAM, supra note 4, 86-89 (noting legal educators are persistently criticized for being stuck in the past).

35 See Cuban, OVERBILD AND UNDERBILD, supra note 17, at 168; Cuban, TEACHING AND MACHINES, supra note 16, at 206; Nancy G. Maxwell, From Facebook to Folsom: Private Blame, How Running Laptops in the Classroom Made Me a Better Law School Teacher, 14 BOND J. L. & TECH. 1, 5-6 (2007) (discussing the negative effect of laptops on student-teacher classroom rapport in law schools); infra p. 290 and accompanying notes.

36 See Cuban, TEACHING AND MACHINES, supra note 16, at 68.
connection between new technology and better student engagement is widely assumed, one of the largest meta-studies to date on the effectiveness of digital classroom tools found no evidence to support that belief.12

In sum, the history of classroom technology shows that pressure to innovate mixed with intuition and assumptions about changing student learning styles can often be a toxic combination.13 Yet legal educators today face even more pressure to “innovate” as schools compete for a shrinking pool of applicants while they also struggle to figure out how best to train students for the challenging job market ahead. Throwing more technology at these issues at least seems like a good solution because it carries many of the right connotations. But unlike classroom experiments of the past, there is substantial evidence that digital technologies in particular can make things worse by lowering student learning outcomes.14 Avoiding that means ignoring the stereotypes about how digital natives learn best and looking instead to learning science to better inform our classroom practices.15


13 CUBAN, TEACHERS AND MACHINES, supra note 16, at 150–51 (observing technology together with unexamined assumptions and unanticipated consequences does not yield good results); Larry Cuban, Pag4 for a Skeptic on Technology, LATEX CUBAN ON SCH. REFORM & CLASSROOM PRACT. (Aug. 16, 2012) [hereinafter Cuban, PAG4s for a Skeptic], https://larrycuban.wordpress.com/2012/08/16/pag4-for-a-skeptic-on-technology/ [https://perma.cc/ZZD-T4DX]; see CAVEN, supra note 7, at 214 (educators do not have good instincts about how students learn); infra pp. 277–78 and accompanying notes.

14 See (Shahid Ali, Proceed with Caution: Technology Faddism and the Millennial Generation, 8 INTERACTIVE TECH. & SMART EDCC: 135, 136–37 (2011) (we should be cautious in using digital technologies because they can cause more harm than good); infra Section III.B.6.

15 “Learning science” is not a perfect solution either because the insights gained by researchers working in a lab under controlled conditions do not always translate to the realities of the classroom. See DRALENE, supra note 7, at 218, 326–27 (though a gap separation knowledge gap the brain cannot detect and two neuroscience sheds indispensable light on how the brain works in ways that can benefit educators); WILDE, supra note 1, at 24–25 (mentioning the brain cannot detect some of the differences). 

16 See CAVEN, supra note 7, at 312–20. Nevertheless it adds an important element of objectivity to a decision-making process that is too frequently informed solely by assumptions and observations about the changing technology habits of our students.
observations about our students' changing technology habits with changes in the cognitive processes that control learning. However, it is the cognitive processes we cannot see, because they occur inside the brain, that are the most important aspects of learning to understand in assessing the compatibility of our classroom methods with the outcomes we seek. The following is a basic overview.

A. Did I Mention the Importance of Attention?

Learning starts by attending to our experiences, which enter the brain as raw sensory data. The amount of data flowing into the brain at any given moment is overwhelming. Consider attending to every sight and sound in your immediate vicinity, including an awareness of your own breathing and every sensation upon your skin. The brain has nowhere near the processing capacity to handle all that. Nor would it have served an evolutionary imperative since the body typically needs enough processing power to solve whatever problem stands between it and survival. Contrary to popular belief, evolution does not favor a big, "smart" brain with lots of computing power. Rather, it favors the smallest, dumbest one for the job, which is the one we got.

pp. 267-69, notes 163-63.
11 See supra p. 232 and accompanying notes.
12 In attempting to provide the reader with a helpful and concise summary of how the brain learns—a notion that scientists tell us is the most complex structure in the known universe and about which we understand only a small fraction of the mysteries that remain—there is a risk of oversimplifying the explanation and some very nuanced material. I have tried to avoid that by sticking to the basics about which a general consensus exists among experts. To the extent my research revealed otherwise, I have so indicated.
14 See DUCK, supra note 9, at 27; GALLAGHER, supra note 76, at 9 (discussing how we are bombarded with so much stimuli, the function of attention is to distill the universe for us); RATZI, supra note 76, at 109; SHELL ET AL., supra note 68, at 15; STURSTEIN, supra note 49, at 57, 59.
15 See GALLAGHER, supra note 76, at 9; RATZI, supra note 76, at 109; SHELL ET AL., supra note 68, at 15; STURSTEIN, supra note 49, at 59, 57.
16 See GALLAGHER, supra note 76, at 9; SHELL ET AL., supra note 68, at 11, 13; STURSTEIN, supra note 49, at 59, 57.
17 See MEDIA, supra note 67, at 32; supra p. 236 and note 67.
18 See PFIZER, supra note 76, at 132-53.
19 Id. at 151-55; PETER J. RICHARDSON & ROBERT ROY, NOT BY GENES ALONE: HOW CULTURE TRANSFORMS HUMAN EVOLUTION 135 (2000) (arguments are engineered to be as stupid as possible but still survive).
20 See WILLEMSEN, supra note 76, at 53-54; SHELL ET AL., supra note 3, at 3 (noting that popular belief, the brain is not designed for thinking but to save us from having to think at all).

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Attention serves the key role of allocating the brain's limited processing capabilities between competing stimuli. A function called "working memory" handles the task by deciding what information to ignore, what gets momentary attention, and what merits further consideration such that it might eventually become "learned." This makes working memory the gatekeeper of all learning.

It does this by directing attention either toward or away from stimuli based on an emotional assessment of its meaningfulness. Sometimes this happens below the level of consciousness while other times we are acutely aware of it, such as "look out for that saber-toothed tiger!" or "I better pay attention because this might be on the exam!" Information captures our attention either because it is intrinsically meaningful, e.g., the smell of a savory meal on an empty stomach, or because it relates to an extrinsic goal or interest, such as earning a good grade at semester's end. Extrinsic goals typically require more effort and motivation to maintain our attention than intrinsic ones.

While unimportant information is ignored altogether, a function called "short-term memory" holds it only for as long as needed to complete the task at hand, like remembering a telephone number. Short-term memory is how the brain handles most of the routine tasks of daily life. Once the task is done, the information is deleted, reflecting an evolutionary adaptation designed to conserve working memory's limited processing capabilities in much the same way a computer's RAM drive deletes data to free-up processing space. For teachers it

80 See RATZI, supra note 76, at 114; SHELL ET AL., supra note 68, at 22-23; STURSTEIN, supra note 69, at 76.
81 See RATZI, supra note 76, at 185-86; SHELL ET AL., supra note 68, at 20-21.
82 See SHELL ET AL., supra note 68, at 13; WILLEMSEN, WHY DON'T STUDENTS LIKE SCHOOL?, supra note 47, at 83, 86 (working memory is the place in the brain where "thinking" happens).
83 See MEDIA, supra note 67, at 32; SHELL ET AL., supra note 68, at 59, 60; WILLEMSEN, supra note 68, at 71-72.
84 See GALLAGHER, supra note 76, at 9 (giving attention means spending one's limited cognitive currency, so you should spend it wisely), MEDIA supra note 67, at 61; SHELL ET AL., supra note 68, at 69, 119, 143.
85 See MEDIA, supra note 67, at 81; SHELL ET AL., supra note 68, at 99, 67; STURSTEIN, supra note 49, at 72, 80.
86 See ROTH, supra note 71, at 13-14.
87 See RATZI, supra note 75, at 134-90; SHELL ET AL., supra note 3, at 20-21; STURSTEIN, supra note 49, at 80, 92.
88 See PFIZER, supra note 76, at 133-35; SHELL ET AL., supra note 68, at 99, 21; STURSTEIN, supra note 49, at 92.
means information that does not make it past students’ short-term memory—either because they did not attend to it very well or their attention was interrupted—is gone and cannot be learned.86

More meaningful information is transferred to long-term memory, where it may be stored among the patterns, or schemas, used for thinking and problem solving.87 To truly become "learned," however, it usually requires that the neurons comprising the relevant pathways be fired again and again through practice and effort to reinforce and strengthen them.88 The more this is rehearsed, the better able the brain is to retrieve that information later.89

Significantly, information processed into long-term memory is typically not stored within a single grouping of neural pathways but among several of them devoted to separate aspects of the experience.90 It will also be wired together with existing pathways related to similar, past experiences.91 For example, sensory data associated with the previously mentioned savory meal will be stored in separate neural pathways relating to its taste, color, and smell.92 Though each network is separate, they are all linked together in a chain.93 Later thinking about that food activates all the pathways in the chain, which working memory assembles into a cohesive thought in the mind’s eye.94 Even thinking about a single aspect of the experience, like the food’s taste or smell, may activate the other pathways as well.95 This is the rationale underlying multimodal learning theory, which posits that instructional methods appealing to multiple senses may encode information more diversely in the brain, which can later aid recall as well as contribute to the breadth of

102 See KAHNMAN, supra note 71, at 22-23 (interfering with attention disrupts our rational, effortful thought processes which diminishes competencies); SHELL ET AL., supra note 68, at 23-24; WELLENSHAM, WHY DON’T STUDENTS LIKE SCHOOL, supra note 68, at 63.

103 See SHELL ET AL., supra note 68, at 12, 50.

104 See CASE, supra note 7, at 94 ("learning requires practice and effort; the more difficult the practice, the greater the benefit"); KAHNMAN, supra note 71, at 230; MEDINA, supra note 67, at 107; KAYE, supra note 76, at 36-37; SHELL ET AL., supra note 68, at 14, 34, 55, 144.

105 See SHELL ET AL., supra note 68, at 18, 24.

106 See PONDER, HOW THE MIND WORKS, supra note 10, at 119-20; SHELL ET AL., supra note 68, at 25.

107 See SHELL ET AL., supra note 68, at 12, 20 (working memory connects new experiences to neural pathways associated with similar, earlier ones).

108 See id. at 12-13.

109 See id. at 12.

110 See id. at 28, 77, 183.

111 See id. at 26-27, 49-52; MEDEIROS, supra note 67, at 208-10; 219; SHELL ET AL., supra note 68, at 26, 77, 183-84.

112 See SHELL ET AL., supra note 68, at 12, 26, 56; WELLENSHAM, WHY DON’T STUDENTS LIKE SCHOOL, supra note 68, at 11-12.

113 See SHELL ET AL., supra note 68, at 38-39, 57-58; WELLENSHAM, WHY DON’T STUDENTS LIKE SCHOOL, supra note 48, at 28-35, 101 ("When it comes to knowledge, those who have more gain more."). "Memory is like a spiderweb that catches new information. The more it catches, the bigger it grows. And the bigger it grows, the more it catches." MEMORIES, supra note 109, at 39.

114 See KAHNMAN, supra note 71, at 98 (humans are pattern seekers); SHELL ET AL., supra note 68, at 97-98; WELLENSHAM, WHY DON’T STUDENTS LIKE SCHOOL, supra note 48, at 30, 101-02 (experts don’t just have more experience than novices; it’s also organized in ways that lets them see patterns others don’t).

115 See PONDER, HOW THE MIND WORKS, supra note 10, at 361; SHELL ET AL., supra note 68, at 56; WELLENSHAM, WHY DON’T STUDENTS LIKE SCHOOL, supra note 48, at 56, 106-07.


117 See SHELL ET AL., supra note 104, at 56; SHELL ET AL., supra note 68, at 2, 10; Jennifer Lee et al., The Impact of Media Multitasking on Learning, 37 LEARNING MEDIA & TECH. 94, 95-96 (2012).

118 See SHELL ET AL., supra note 58, at 13, 19, 27; David Glenn, Divided Attention, CRON. HIST. EDUC. (Feb. 28, 2010), http://chronicle.com/article/Scholars-Turn-Their-Attention/62756/ ("the brain is designed to let us "walk and chew gum at the same time, but not walk, chew gum, play Froboz, and solve calculus problems").

119 See Lee et al., supra note 108, at 96.

119 See PONDER, supra note 104, at 61; SHELL ET AL., supra note 68, at 27-28, 49-52; Teaching the Digital Caveman 259
trying to remember the ten random digits comprising a typical telephone number over-taxes most people’s working memory, but by grouping them according to area code, exchange, and subscriber number, working memory treats those ten bits of information as three, which most people can process.118

By comparison, working memory’s ability to attend to more than one task at a time is even more tightly constrained. In truth, it does not exist because it is basically impossible for the brain to “multitask” beyond activities that are so automated, like walking and chewing gum at the same time, that they require no attention.119 So, what looks like multitasking to the casual observer is actually “task-switching.”120 Studies show that students who move back and forth between tasks take more time to complete each one and both are performed with much less proficiency.121

When educators first saw students multitasking in class, many assumed it was a new learning style resulting from constant exposure to digital technology.122 But seeing it through the lens of learning science shows it instead to be a maladaptive learning behavior.17 In describing the results of a leading research study on the effects of multitasking on the brain, one of its authors, Stanford Professor Clifford Nass, observed: “We were

113 See GALLAGHER, supra note 70, at 156; DANIEL J. LEVIN, THE ORGANIZED MIND: THINKING STRAIGHT IN THE AGE OF INFORMATION OVERLOAD 16, 90 (2015); MIZUNA, supra note 67, at 85; SHELL ET AL., supra note 68, at 56-58 (to the extent any task requires attention, we can only perform one at a time; everything else is task switching); STEINBERGER, supra note 46, at 81. See generally Eddy Ouyed et al., Cognitive Control in Media Multitasking, 106 PROC. NATL. ACAD. SCI. U.S. 15093 (2009) (loudly widely cited for the proposition that the ability to multitask does not exist); infra p. 201 and note 115; infra p. 207 and notes 103-05.
114 See GALLAGHER, supra note 76, at 152; SHELL ET AL., supra note 68, at 31, 58.
115 As discussed in Part III, there is a robust body of evidence showing that students who task-switch during class learn less and perform more poorly on tests, in some cases significantly so, compared to unitaskers. See GALLAGHER, supra note 76, at 153; MIZUNA, supra note 67, at 84 (a person interrupted in a task can take up to fifty times longer to complete it); POWERS, supra note 5, at 59 (one minute of interruption requires fifteen minutes of recovery time); LEE ET AL., supra note 108, at 705 (“[d]istracting interfere[s] with knowledge acquisition. It generates excessive cognitive load that burdens the working memory.”); see generally Susan M. Bartels et al., Non-academic Internet Use in the Classroom Is Negatively Related to Classroom Learning Regardless of Intellectual Ability, 18 COMP. & EDUC. 108 (2014) (reporting research results that are consistent with prior studies finding a strong relation between the use of wireless devices in class and learning).
116 See GLENN, supra note 109 (noting that some professors argue we should accommodate multitasking behaviors because “[f]or the basic tenets of good teaching is that you have to start where the students are”).
117 See infra pp. 282-83 and accompanying notes.

absolutely shocked... [M]ultitaskers are terrible at every aspect of multitasking. They’re terrible at ignoring irrelevant information; they’re terrible at keeping information in their head nicely and neatly organized; and they’re terrible at switching from one task to another.”121 To dispel any remaining belief that constant exposure to technology can alter the brain by conferring multitasking superpowers, learning science suggests there are physiological and neurobiological constraints that make it impossible.119

All evolutionary adaptations like working memory reflect a trade-off between the needs of survival and biology.122 Back in the day, the caveman had no need to multitask beyond walking and swinging a club at the same time.123 Upgrading the brain’s processing capabilities to confer bona fide multitasking powers would have been expensive in physiological terms.122 The brain comprises only two percent of the body’s total weight but already consumes twenty percent of its energy and nutrients.123 If expanding working memory’s ability to process information required additional brain tissue, it would have meant diverting even more bodily resources to deliver the sustenance a bigger brain would need.124 And assuming a larger brain would also need a bigger head to contain it, childbirth would have been impossible without also killing the mother, not to mention that a bigger, babbling head would have made the caveman more susceptible to fatal injuries in a fall.125 That natural selection
opted to give him the efficient, economy version of working memory instead of the gas-guzzling luxury model reflects an evolutionary compromise worthy of King Solomon himself, given the alternatives.

Two other aspects of attention are important to mention for purposes of this discussion. The first is that the brain is not very good at it.126 For most of us, attention quickly starts to drift on its own after a few minutes despite our best efforts to stay on task.127 Though this is poorly suited to many school and work related tasks associated with contemporary life, it is a trait that was highly advantageous to the caveman.128 To survive, our nomadic, hunter-gatherer ancestors had to remain constantly alert to the presence of potential prey and threats from predators.129 Research confirms that a caveman with ADD was a much better hunter than his buddies with stronger attentional abilities, a finding that caused one expert to quip that if Ritalin had been around back in the day, the survival of our species may have been in serious doubt.130 But getting stuck with the same distracted brain today, however, is a distinct disadvantage to any student trying to survive their first year of law school.

Niche, supra note 134, at 6995.

126 See CAREY, supra note 7, at 315, 317 (the ability to concentrate as emphasized by the contemporary model of formal schooling is a mirage that does not exist because the brain was designed in forge and avoid predators, not sit still in class); SHELL ET AL., supra note 68, at 13, 15, 29 (it takes effort to sustain attention for more than thirty seconds); SYLVESTER, supra note 49, at 129.

127 See GALLAGHER, supra note 78, at 148-49; MEDINA, supra note 67, at 74, 90 (research indicates that the average attention span is ten minutes, after which it typically plummets to zero); SHELL ET AL., supra note 68, at 13, 15, 29.


129 See Eisenberg & Campbell, supra note 126; Richard A. Friedman, A Natural Fix for ADHD, N.Y. TIMES (Oct. 31, 2014), http://www.nytimes.com/2014/11/01/health/science/friedman-qanda-natural-fix-for-adhd.html?_r=0 (perma.cc/RTJN-LCXX) ["As hunters, our caveman ancestors had to adapt to an ever-changing environment where the dangers were as unpredictable as the next meal... [Having a] rapidly shifting but intense attention span and a taste for novelty makes a person highly advantageous in locating and securing rewards—like a mate and a nice chunk of mastodon. In short, having the profile of what we now call ADHD would have made me a Paleolithic success story.

130 See supra notes 139-29.

131 See GALLAGHER, supra note 76, at 7 ("The distractibility that served our foragers so well is a big drawback for post-industrial folks living in a world with lots of distractions.

132 AMERICAN PSYCHIATRIC ASSOCIATION, DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS 59-63 (Am. Psychiatr. Ass'n ed., 5th ed. 2013) (attention deficit disorder is a recognized learning disability characterized by symptoms that include being "usually distracted by extraneous stimuli"); see GALLAGHER, supra note 76, at 17, 148, 149 (ADD is only considered a disability because modern, western society places a high value on the ability to pay attention).

133 See CAREY, supra note 7, at 215, 217 (our modern system of education mistakenly assumes it is based on how the brain works; it is such [SYLVESTER, supra note 49, at 71].

134 SCHRAN, TEACHING MINDS, supra note 14, at 307-08; see PINKER, HOW THE MIND WORKS, supra note 13, at 301 ("Natural selection... did not shape us to earn good grades in science class...").

135 See GALLAGHER, supra note 76, at 10 ("'Focus is a skill, which has any other takes discipline and effort to develop.'"); SYLVESTER, supra note 49, at 83.

136 See GALLAGHER, supra note 76, at 26; PINKER, HOW THE MIND WORKS, supra note 10, at 377; SHELL ET AL., supra note 68, at 79.

137 See PINKER, HOW THE MIND WORKS, supra note 10, at 375-77; SHELL ET AL., supra note 68, at 29-31 (attention is designed to shift on the new and novel); Friedman, supra note 130.

138 See LEVITH, supra note 113, at 95, 101-02; RAYE, supra note 76, at 116-17.

139 See NICOLAS CARR, THE SHALLOW: WHAT THE INTERNET IS DOING TO OUR BRAINS 116-17, 129, 194 (2013) [every time we go on the Internet we are training our brain to be distracted]; LEVITH, supra note 113, at 103-02 (make no mistake—checking
Zappos, or smoking crack, each of those behaviors contributes to a bio-feedback loop in the brain that encourages more of the same. The implication for teachers is that although wireless devices can be powerful learning tools, giving one to a caveman during class and then expecting him to stay on task is like buying a Prius thinking it will put the polar icecaps back. It’s a noble thought, but don’t hold your breath.

B. The Fantastic Plastic Machine

One of the brain’s most impressive characteristics is a feature called “neural plasticity.” While working memory controls the flow of information that serves as the raw material for everything we learn, neural plasticity is what builds the circuitry in the brain to support it. As the name implies, it is a flexible function that accounts for all the knowledge, skills, thoughts, and beliefs we acquire in our lifetime and why they may also change over time. Insofar as any of the foregoing are shared by members of our extended social group, neural plasticity is what accounts for all human culture. Indeed, a reciprocal relationship exists between the two in that inventions like the smartphone, a product of neural plasticity, may influence the culture at large which in turn may influence the thoughts and behaviors of the group members.

Neural plasticity was an evolutionary adaptation that gave our ancestors the cognitive flexibility to learn the tool-making, foraging, and other skills needed to survive during a time of dramatic climate change that would have given Al Gore fits. In geo-historical terms, neural plasticity is linked to the Pleistocene age, which began approximately 1.8 million years ago and lasted until about 10,000 BC. It was a period characterized by several

small and Facebook are neural addictions; RAY, supra note 78, at 118.
142 See LEVITIN, supra note 113, at 196-98; RATEY, supra note 76, at 118.
143 See RICHTER & BOYD, supra note 82, at 64-66, 71, 145-47.
144 See PENKER, supra note 82, at 10, 34, HENRY FLOTNER, NECESSARY KNOWLEDGE 331, 365 (2007).
145 See RICHTER & BOYD, supra note 82, at 63, 136, 145-47, 156-61.

146 See RICHTER & BOYD, supra note 82, at 15-22. See generally RICHTER & BOYD, supra note 82, at 45, 113, 145-47, 156-61. 139 supra note 9 (discussing from a phenomenological perspective that technology, like all environmental influences, can change the content of our thoughts but not the mechanisms that create them).
147 See RICHTER & BOYD, supra note 82, at 131-36, 146-47; see also Leda Cosmides & John Tooby, Evolutionary Psychology, Moral Heuristics, and the Laws, in HEGEGIES AND THEIR LAW 181, 184-85 (Gary Gigerenzer & Christopher Engel eds., 2008).

rapping cycles of glacial expansion and retreat that saw many species perish.146

Natural selection favored those creatures with the intellectual firepower needed to figure out within their own lifetime solutions to the problems associated with survival that otherwise would have taken Darwinian evolution millions of years to sort out.147 It was like an aftermarket bolt-on accessory that gave a few lucky critters the problem-solving ability to sprint ahead of everyone else in an evolutionary footrace where placing second meant getting turned into a fossil.148 Thus, cognitive scientists say it is no coincidence that an increase in brain size among many mammals, including the caveman, coincides with the Pleistocene period.149

Despite its impressive versatility, however, neural plasticity has no more ability to change the brain’s information processing architecture than software can change the hardware that runs it.150 Students who practice multitasking might improve their typing skills, but transcending the tightly circumscribed limitations on working memory’s ability to toggle between a few simple tasks at once is a bridge too far.151 On the other hand, neither can neural plasticity fry our students’ brains by making them permanently more distracted as some lay commentators
have alarmingly claimed.\textsuperscript{12} Increased distractibility may be an occupational hazard of technology use, but it is a learned behavior, that can be unlearned as well, rather than a permanent change in brain structure.\textsuperscript{13} To paraphrase Harvard cognitive scientist Professor Steven Pinker, if you want to be less distracted, stop getting distracted.\textsuperscript{14} If our students appear distracted in class because of wireless devices, the solution is not to enable that behavior further but to take steps to help them build better attentional abilities.

The assertion that technology has changed the way our students think and learn first appeared in a 2001 essay by Marc Prensky, an educational consultant at the time.\textsuperscript{15} It is the same five-page essay in which he coined the phrase “digital native,” sending legal educators into a tizzy ever since.\textsuperscript{16} Author Nicholas Carr, among others, made a similar claim in his best-selling book The Shallows: What the Internet Is Doing to Our Brains.\textsuperscript{17}

Cognitive scientists, however, scoff at this notion, pointing out that of course the brain gets rewired every time we interact with environmental influences like technology.\textsuperscript{18} That is exactly how neural plasticity is supposed to work in helping us learn new things.\textsuperscript{19} The brain does indeed build new neural pathways to support nearly everything we learn just as when we stop doing those things, the pathways decay.\textsuperscript{20} But it does not mean neural plasticity can alter the brain’s fundamental thinking and learning characteristics.\textsuperscript{21} As proof, some point to studies showing that the heaviest multitaskers do worse on tests that measure multitasking proficiency compared to those who do it less.\textsuperscript{22} If the Internet was really changing our students’ brains, you would expect the heaviest multitaskers to show improvement, not the opposite.\textsuperscript{23}

And despite some impressive characteristics, neural plasticity, like working memory, is “severely” constrained by our genetic programming with respect to how and what we are
capable of learning. Known as the theory of "inmate intelligence," experts say that the brain comes factory-equipped with preinstalled templates for interpreting the world in tightly circumscribed, uniform ways across several key knowledge domains including intuitive physics (e.g., a basic understanding of cause and effect), logical reasoning (e.g., an ability to draw inferences), intuitive psychology (e.g., recognizing others have motives and intentions), and rudimentary mathematics, among other areas, that comprise the fundamental assumptions we all share about how the world works. In the absence of these constraints, from the moment of birth forward, learning for each of us would consist of an "unguided cognitive gymnastic" through life.

Neural plasticity is probably too tightly constrained by our genetic engineering for technology to have much, if any, effect on it. In short, technology is not changing the brain in any significant way as some educational consultants and lay commentators claim; rather technology is changing to become more compatible with the way the brain works.
bestselling book, Thinking Fast and Slow.⁷⁴ The caveman did not have the luxury of naval gazing or reflectively sifting through all the evidence before deciding how best to respond to threats or opportunities.⁷⁵ Rather, he needed to decide "right now" whether the other guy posed a threat, suss out the weaknesses of a potential mate, or identify cheaters in the group who threatened the social contract.⁷⁶ Professor Kahneman refers to this type of quick, intuitive thinking as "System 1."⁷⁷ Because it relies on partial information and subconscious heuristics, System 1 thinking often contains mistaken assumptions and biases that a more careful assessment of the facts would lay bare.⁷⁸

Professor Kahneman refers to the deliberate, analytical thinking we teach in law school as "System 2."⁷⁹ Unlike intuitive System 1, System 2 thinking is innately difficult and effortful.⁸⁰ But the caveman brain is lazy—indeed the very purpose of System 1 is to save us from having to think at all—so it would much rather avoid the heavy-lifting that System 2 requires.⁸¹ This means for law professors is that we will be most effective when challenging students in ways that show them their intuitive, "common sense" solutions to the problems we pose will not work. Professor Kahneman tells us that, generally speaking, it is only after System 1 breaks down that System 2 takes over, applying logic and reason to work on the problem at hand until it finds a solution.⁸²

The foregoing might lead one to wonder that if the caveman brain is designed for System 1, fast-and-frugal solutions to the problems associated with living as part of a nomadic, foraging tribe of socialites, why would evolution also give it the intellectual firepower of System 2 which we use today to solve calculus problems, send a man into space, and invent online shopping?⁸³ The caveman, after all, did not need to do any of those things to survive. If evolution is such an efficient mistress, what purpose did System 2 serve?⁸⁴

The premise of evolutionary psychology is that the cognitive abilities we use today to solve the problems of modern life have all been repurposed from the ones our ancestors used to survive on the African savannah.⁸⁵ Though our brain was never designed for the critical thinking skills we teach in law school, students are still able to do it, with great effort and difficulty,

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⁷⁴ Kahneman, supra note 71, at 90–91 (Professor Kahneman is a Nobel Prize winning cognitive scientist).
⁷⁵ See Davis, supra note 9, at 37 (claiming that had our ancestors been required to spend their full intellectual resources on every problem they faced, it would have been a recipe for disaster); Kahneman, supra note 71, at 39; Stuvens, supra note 49, at 71, 73; Williams, Why Don't Students Like School, supra note 48, at 3–4.
⁷⁶ See Kahneman, supra note 71, at 90, 245; Pinker, How the Mind Works, supra note 10, at 403, 415; Comer & Teas, supra note 144, at 184; Mark Schaller, Evolutionary Bases of First Impressions, 1 FIRST IMPRESSIONS 1, 3 (Nalini Ambady & ed.). 2009 (claiming that for survival purposes, you were better off falsely assuming the worst about the other guy than incorrectly assuming the best about him).
⁷⁷ Kahneman, supra note 71, at 24.
⁷⁸ Id. at 24, 86, 105 (stating that "System 1 generates impressions, intuitions, and "feelings," which "System 2" operates "out of sheer laziness", which is what transforms intuition into "belief"); see Davis, supra note 9, at 58 (claiming that heuristic thinking can often result in humans ignoring most of the information available to them); Pinker, How the Mind Works, supra note 10, at 312–13, 344 (asserting that our brain likes to put things into boxes and organize the world according to stereotypes which are not always accurate).
⁷⁹ System 1 is so deeply ingrained in the way we think because it draws on accumulated experience and emotions. Indeed, it can be so compelling that it overrides rational thought even among those people who are trained to be dispassionate and analytical. In the book Make It Stick: The Science of Successful Learning, the authors discuss just such an example involving commercial airline pilots who relied on System 1 emotionally-driven intuitive thinking rather than trust the airplane's instruments on their training and reasons would dictate, resulting in tragic consequences. Peter C. Chip, Joseph E. Berndt ET AL., Make It Stick: THE SCIENCE OF SUCCESSFUL LEARNING 208–09 (2014). This point being that it can be very difficult for a teacher to get students to engage System 2's logical reasoning rather than defaulting to System 1's emotionally-driven intuition. Id.
⁸⁰ See Kahneman, supra note 71, at 31.
⁸¹ See id. at 31, 35, 45–46, 81, 99, 162 (System 1 is characterized by intellectual sloth while System 2 is the skeptic); Pinker, How the Mind Works, supra note 10, at 34–49 (because of the existence of System 1 thinking, watching college students work on logic problems is not a pretty sight); Williams, Why Don't Students Like School, supra note 48, at 4.
⁸² See Davis, supra note 9, at 47–48; Davis & Davis, supra note 4, at 98.
⁸³ See Davis, supra note 9, at 57–58 (heuristics are a form of intellectual laziness); Kahneman, supra note 71, at 34, 37, 86 (laziness is built deep into our nature; the brain would rather endorsing intuitive solutions generated by System 1 than do the hard work required to make a critical assessment under System 2); Pinker, How the Mind Works, supra note 10, at 307–09 (the brain did not evolve to be a good scientist; it did not evolve for "truth"—it evolved to put things into categories and draw inferences from them); Williams, Why Don't Students Like School, supra note 48, at 3 (the brain is designed to save us from thinking).
⁸⁴ Some cognitive scientists theorize that multitasking and other distracting behaviors are a form of distraction to help us avoid System 2 thinking. See Glenn, supra note 109. This, of course, is another independent reason to ban wireless devices from the law school classroom in particular.
⁸⁵ "This book has been repurposed from the one our ancestors used to survive on the African savannah. Though our brain was never designed for the critical thinking skills we teach in law school, students are still able to do it, with great effort and difficulty," Teaching the Digital Caveman.
because, as evolutionary psychologists tell us, being a caveman back in the day took a lot more smarts than first meets the eye.185

Life back then was like being on a camping trip that lasted the rest of your life, but without the tent, Swiss Army knife, flashlight, space blanket, or freeze-dried linguine.186 To be a successful hunter, you had to out-think your prey to anticipate its next move.188 You also needed the analytical acumen to read the minds of others based on split-second social cues.189 And don't forget those vexing climate change issues we still haven't figured out. It goes to show that the only difference between knowing whether your fellow caveman wants to "friend" you or beat you to a pulp and solving the problem of sustainable nuclear fusion is just a matter of degree.

The implications for legal educators are at least two-fold. First, it tells us the brain is not very good at "thinking like a lawyer."190 While students rise to the occasion, the law school curriculum will always remain innately difficult and effortful.191 Hope springs eternal that technology can save students, and us, from some of the drudgery, though history reminds us that fools rush in where angels fear to tread.192 Adopting new technologies we do not fully understand in an "unrehearsed search," in the words of Professor Cuban, for learning efficiencies that may not even exist, can easily make things worse by reinforcing lazy caveman intuitive thinking instead of promoting effortful System 2.193

184 See DAVIS, supra note 9, at 44–45 (the ability to peer into the mind of another based on characteristics not physically obvious takes great intellectual prowess); PINKER, HOW THE MIND WORKS, supra note 15, at 381 (protesting as a foregone back in caveman days required more smarts than being a good chess player today).

185 See PINKER, HOW THE MIND WORKS, supra note 15, at 188, 375; COSIMIDE & TOSKAS, supra note 144, at 185.


187 See SCHALLER, supra note 176, at 3–3; see also WOLFEH, supra note 49, at 53–54 (the brain evolved to make quick, intuitive, stereotyped decisions, not accurate ones); see supra p. 278 and notes 175–176.

188 See CARKH, supra note 7, at 82 ("school" learning feels difficult because it is); PINKER, HOW THE MIND WORKS, supra note 15, at 42, 240–42, 256–59 (our minds were adapted for the Stone Age, not the Computer Age); SHELL ET AL., supra note 68, at 66–67, 122; WELLMAN, WHY DON'T STUDENTS LIKE SCHOOL, supra note 45, at 3–5.

189 See DESLINGS, supra note 7, at 303 (the brain never evolved to do schoolwork like reading); STEVEN PINKER, THE BLACK SLAVE 233, 342 (2002) (much of formal education is "arbitrarily unnatural" and masquerading as is not easy despite the mantra that "learning is fun"); SHELL ET AL., supra note 68, at 15, 66–67, 122.

190 See supra Part I.

191 See CUBAN, TEACHERS AND MACHINES, supra note 16, at 79 (Professor Cuban describes educators as being in an "unrehearsed" pursuit of teaching efficiencies through technology).

192 See supra Part I.

193 See CUBAN, TEACHERS AND MACHINES, supra note 16, at 73 (Professor Cuban describes educators as being in an "unrehearsed" pursuit of teaching efficiencies through technology).

Second, with so much focus on technology, it is easy to overlook that the most effective classroom tool we have is the ancient caveman mind-meld technique that enables us to tell at a glance whether students are "getting it" or not so we can make appropriate adjustments.194 The brain is a far more sophisticated computer than the love-child of IBM’s Watson and Sergey Brin could ever hope to be.195 And while many teachers may be unaware of the evolutionary underpinnings, it is why we have always placed great importance on good classroom rapport.196 The concern that putting "machines" in the classroom may interfere with that is a legitimate one, which we must continue to zealously protect.197 It is the reason MOOCs are "lousy" and why the social media "revolution" that promised to make us more connected is instead making us isolated and lonely.198 The brain is designed for real interaction, not the virtual kind.199 Technology offers incredible learning opportunities, but student success will always depend first and foremost on the human touch, which means what they need from us most is face-time, not Facebook.200

194 See DAVIS, supra note 9, at 67–68 (the ability to read students’ minds to tell whether they are confused, or engaged, may be the single most important asset of a good teacher and doing it well likely predicts the good ones from the bad).


196 See MEZNER, supra note 67, at 45 (there is plenty of empirical support for the proposition that the quality of an education depends on the relationship between the teacher and students); EVERT MOOROOG, TO HAVE EVERYTHING, CLICK HERE 9 (2013) (President of Williams College says research shows the best predictor of student intellectual success is the amount of face-to-face contact with professors); WOLFEH, supra note 49, at 128.

197 See supra p. 353, note 60.

198 See LEVTIN, supra note 113, at 127, 130–31 (social media is not an adequate replacement for real interactions); SHERRY TURGEON, ALONE TOGETHER: WHY WE EXPECT MORE FROM TECHNOLOGY AND LESS FROM EACH OTHER passion (2012); ROBERT P._Provine, Internet Society, is It IN THE INTEREST of CHANGING THE WAY WE THINK?, supra note 5, at 168, 168 ("psychologist:networksWant says that face-to-face contact is the "gold standard" of interpersonal communication); supra p. 264 and notes 26–27, supra p. 263 and note 66.

199 See PINKER, HOW THE MIND WORKS, supra note 15, at 436; Provine, supra note 198, at 168; WOLFEH, supra note 49, at 128.

200 See MEZNER, supra note 67, at 45 (the ability to learn has deep roots in relationships); MOOROOG, supra note 196, at 9; OPPENHEIM, supra note 19, at 397 (education depends on meaningful contact between a good teacher and an inspired student).
D. The Eyes Have It: The Reality and Myths of Visual Learning

A pervasive assumption about "digital natives" is that they are mostly visual learners who do best with screen-based technologies. The assumption is grounded in "learning style" theory, which posits that every student has a unique way of learning based on one of the main senses like sight or hearing. Thus, a "visual learner" should learn best when the teacher uses visual modalities like PowerPoint, while an "auditory learner" learns best listening to a verbal explanation.

The theory is easy enough to prove by showing that visual learners test better after looking at a pictorial explanation of the material versus a lecture and vice versa for auditory learners. Though several studies have looked for evidence to support learning style theory, none has been found. Professor Daniel Willingham, an expert on cognitive science and learning, points out that common sense tells us that even a student claiming to be an auditory learner will not, for example, learn geography better by listening to a description of the countries' shapes rather than looking at a map. Neither will a visual learner learn a foreign language by studying the alphabet instead of listening to a pronunciation of the words. The best way to teach and learn any subject is to employ the methods that are most compatible with the desired outcomes. Using visual technologies in the mistaken belief that "digital natives" learn best this way will have negative consequences if, because of that mistaken assumption, we overlook another modality that is better suited to the objective.


201. Willingham, Learning Styles Are a Lost Cause, supra note 200.

202. See WILLINGHAM, WHY DON'T STUDENTS LIKE SCHOOL, supra note 48, at 120; Willingham, Learning Styles Are a Lost Cause, supra note 201.

203. See SHELL ET AL., supra note 68, at 201; WILLINGHAM, WHY DON'T STUDENTS LIKE SCHOOL, supra note 48, at 118-19; Willingham, Learning Styles Are a Lost Cause, supra note 201.

204. See WILLINGHAM, WHY DON'T STUDENTS LIKE SCHOOL, supra note 48, at 120-21; Parker, supra note 203, at 119; Willingham, Learning Styles Are a Lost Cause, supra note 201.

205. See id.

206. See BROWN ET AL., supra note 178, at 145-46 (because no evidence supports learning style theory, teachers should focus on trying to match the instructional methods with their classroom goals because at least that strategy has a basis in empiricism).

But even if learning styles existed, learning science makes it abundantly clear that digital natives are no more visually-oriented than anyone else. That is because the entire species evolved to be highly visual, not just the recent few who grew up looking at screens. Vision is by far the brain's most dominant sense, though haptics gives it a run for its money. Vision takes up more neurological real estate than all the other senses combined. The eyes are also the only sensory organs that do not do double duty like the ears or nose; their sole purpose is to transmit visual data to the brain.

Evolutionary theory tells us that vision is so dominant because there is a strong correlation between it and survival. Simply put, you cannot find food and avoid predators if you cannot see them. Among the advantages, a good set of peepers made the caveman a more successful hunter and gatherer. Because natural selection also gave him the deluxe color edition, a rarity in the animal kingdom, he ate better than his fellow forest critters since he could tell which fruits were ripe based on their bright colors. But wait, there's more—because the caveman also got the rare stereoscopic package which enabled him to move better in the forest and grab food with his hands.

Having 3-D vision also meant the caveman could see objects positioned in space in relation to each other. Because of this, evolutionary psychologists theorize that stereoscopic vision contributed to the development of our analytical mind. The theory goes like this: all analytical thinking is based on comparisons, the caveman's ability to perceive objects in relation to each other is the reason the legal analysis we teach in law school today is based on comparing the facts of one case to another. If not for 3-D vision, who knows what "thinking like a lawyer" might mean instead!

207. See FINNIS, THE MIND WORKS, supra note 10, at 214 (we are highly visual creatures because our mind actually evolved around that sense).

208. See id. at 181; SYLWERT, supra note 49, at 61; infra Section III.D.-E.

209. See MEDEA, supra note 67, at 231-32 (about half of the brain's resources are devoted to vision; it is the "dictatorial emperor"); SYLWERT, supra note 49, at 61.


211. See id.

212. See id.

213. See id.

214. See id. at 191-94. Because of this, a "founded and intimate" connection evolved in the brain between the eye and hand that has many important implications for teachers. See supra p. 278 and notes 224-25; supra p. 389 and notes 350, supra p. 381 and note 309 (this ancient connection enables the brain to unify and coordinate the eye, hand, and attention all in one place, at one time).


216. See id. at 191-92.

217. See id. at 191.
Linguists posit that vision also played a key role in the development of language. According to this theory, the oldest form of communication was purely visual, based on a vocabulary of physical gestures that later became the grunts and groans of a proto-language before morphing into modern, spoken language. Thus, the caveman, not digital natives, was the "OOG" visual learner, relying on observation and imitation for all communication. Spoken language only came along much later, replacing the caveman pantomime routine, which had no doubt grown tiresome by then. Of course, that's when things got really interesting, because words allowed our forebears to communicate in abstract ideas. The rest, as they say, is history.

Some experts believe an ancient connection still exists between brain circuits devoted to language and physical movement. They argue it helps explain the research discussed in Section II.D.5 that tangible media like books, which students must physically manipulate to use, can enhance learning compared to their electronic counterparts. It is also consistent with the theory of embodied cognition, which says that because the mind and body evolve together, with each heavily informing the design and function of the other, a profound connection still exists between them in all cognitive activity. In effect, we think with our mind and body.

III. STRATEGIES FOR USING CLASSROOM TECHNOLOGIES

Even a Caveman Would Love

Based on the foregoing, this Part offers strategies informed by both history and learning science for using several popular classroom tools in ways that promote the skills needed to "think like a lawyer." This includes suggestions for making better use of laptops, visual tools like PowerPoint, reading technologies, and writing technologies. Also included is a summary of two of the largest meta-studies to date that analyzed the overall effectiveness of classroom digital teaching technologies based on a review of thousands of independent studies. Before getting to the specifics of each of these discussions, however, the following are some general guidelines to consider whenever contemplating the use of a new classroom technology based on a synthesis of the many studies cited in this section.

A. General Guidelines

Experience tells us that the best place to start whenever considering the use of a new classroom technology is to identify a good reason for using it and then ask whether it serves that purpose better than the alternatives. Forgetting learning styles—this is about trying to create a good match between the classroom tools available to us and our learning objectives. Experience also tells us that new technologies work best when used to fill a pedagogical niche not addressed by existing options.

Conversely, they have a history of failing when the teacher

219 See Palardy, supra note 7, at 109 (best practices for technology use in law school means knowing when not to use it). See also id. at 115 ("best practices" for law school means using technology when it serves a specific pedagogical purpose).

218 See Pinheiro, The Mind’s Eye, supra note 10, at 374, supra note 76, at 173, supra note 69, at 49, at 57 (one skin is where the brain meets the outside world); Frank B. Wilson, The Hand: How It’s Use Shapes The Brain, LANGUAGE AND CULTURE 286, 289 (1980) (the clear message from biology to educators is that the most effective teaching techniques aim at using, not divorcing, mind and body). Branden Kronick, The Science of Memory, 54, 56 (Sept. 29, 2014) (http://www.scienceoflearning.com/the-science-of-handwriting) (the mind-body connection is paramount); we use our hands to access our thoughts.


merely substitutes a new, more novel tool for one that is already serving its purpose well.251

Related to this is the “more is better” fallacy of classroom technology; if adding a little is good, than adding more must be even better.252 For example, visual technologies like film, video, and PowerPoint have become an indispensable part of every teacher’s classroom repertoire because they fill a niche that other tools cannot. Yet they have failed to replace textbooks, despite several efforts over the past 100 years, because print is often more compatible with many classroom objectives such as helping students develop critical thinking skills.253

As this suggests, the medium matters in assessing how well a particular technology promotes the teacher’s learning objectives. Part II tells us that the cavernous, like Madonna, was built for a material world, not a virtual one, in which mind and body work together in all cognitive activity.254 Research on classroom technology is consistent with this insofar as tools that incorporate tactile, or “haptic,” characteristics like books, pens, and paper are effective multimodal learning tools that help promote critical thinking by more deeply engaging students both visually and physically.

Teaching students to “think like a lawyer” means that we must also consider whether our classroom tools provide important foundational skills like attention and focus.255 The relationship between the ability to pay attention and success in school is well established, as is the one between interruptions with attention and weaker learning outcomes.256 Since wireless devices are the chief source of unwanted disturbances in the classroom, we must continually weigh how well their use promotes our objectives against the distractions they cause. Sometimes this will tip in favor of using these devices, while other times we need to turn them off in favor of an alternative.

A primary rationale for using new technology in the first place has always been the assumption that it helps motivate students to learn. However, one of the largest meta-studies to date on the effectiveness of digital classroom technologies found no evidence to support that widely held belief.257 Rather, the researchers found that new technology may enhance initial student interest but that does not lead to better learning outcomes unless the teacher is also able to leverage it into more helpful work.258 This suggests that adopting a new technology solely for the purpose of better motivating students may actually be counterproductive if it is not otherwise well-suited to the particular learning objective.

B. “Should I Stay or Should I Go?”: What to Do About Laptops

Law schools began making laptops mandatory and installing wireless connections in the late 1990s as both were becoming increasingly popular outside the classroom.259 Some administrators saw the opportunity to brand their schools as “early adopters” which conferred instant status as innovators.260 The decision to install these technologies was also motivated by better attentional abilities equals better learning; Megan M. McClelland et al., Relations Between Preschool Attention Span, Persistence, and Age 25 Educational Outcomes, 29 Early Childhood Res. Q. 314, 315–18 (2012) (attention span is especially relevant to doing well in school and academic attainment); Glenn, supra note 258 (strong attentional abilities produce stronger fluid intelligence); infra pp. 285–85 and accompanying notes.

251 DURHAM STUDY, supra note 228, at 4, 8; PALFREY & GASHER, supra note 23, at 246 (educators make a mistake when they surmize what works in favor of using the newest, coolest tools); supra p. 231 and notes 66–68.

252 See DURHAM STUDY, supra note 228, at 6, 31; see also PALFREY & GASHER, supra note 23, at 244–47 (there is a tendency to over promote and fetishize the use of technology when it comes to digital natives; that instinct is wrong); supra Part I.

253 See CUBAN, TEACHERS AND MACHINES, supra note 16, at 8 (textbooks have evolved because they are available); Palfrey, supra note 7, at 136 (at Harvard Law School, you’ll still see lots of old-fashioned brand textbooks being used because they remain an effective technology for conveying information to students); supra pp. 347–48 and accompanying notes, infra Section II.D.

254 MADONNA, Material Girl, in DISMALLIC CULTURE (See Records 1980); see POWERs, supra note 5, at 130–54 (physical tools are actually easier on the mind than electronic ones because they allow the human to off-load some of the cognitive burden to the body); WILSON, supra note 233, at 296, 298; James Miroupe & M. Carl Jones, Haptics in Education: Exploring an Untapped Sensory Modality, 76 Rev. Educ. Res. 317, 317–19 (2006); supra p. 276 and notes 255–33; infra p. 296 and accompanying notes.

255 See GALLAGHER, supra note 76, at 16, 67 (studies increasingly show we can cultivate deep attention through practice and discipline).

256 See NEJINA, supra note 87, at 74 (research spanning 100 years clearly shows that
an “academic moral panic” over the supposedly changing learning styles of digital natives.241 As the unintended consequences of these decisions came to light, it has led to more debate among law professors than any other technology issue in recent memory.242

The chief issue is whether students are missing laptops during class in ways that interfere with their learning and what, if anything, professors should do about it. Some take a laissez-faire approach, believing that law students are adults who should make their own decisions about what they do in class.243 Others have responded by banning laptops altogether, including, ironically, the co-founder of Harvard’s Berkman Center for Internet and Society, Professor Jonathan Zittrain.244 Still others have invested considerable time and effort trying to figure out what exactly students are doing on their laptops before deciding on a policy.245 Finally, some have created laptop-free zones in an effort to accommodate each student’s preference.246

The various responses reflect the degree to which professors have earnestly struggled to find a good solution that balances all the interests involved. Nonetheless, each of these strategies has problems. Banning laptops altogether means giving up a great interactive, multimodal learning tool that lets students explore subjects on their own during class. Relying on student opinion to set classroom policy is problematic because at

241 See supra p. 263 and note 5; see also supra p. 247 and note 18.

242 A quick search in WestlawNext for articles discussing the use of laptops in law school turned up more than 100 results. Among the many, see DeGriff, supra note 56, at 208 (citing several articles discussing these issues).

243 I have no cites to offer because professors who take a laissez-faire approach generally do not write articles outlining the virtues of doing nothing.

244 Tracy Jan, Tangled in an Endless Web of Distraction, BOSTON.COM (Apr. 24, 2011). See also http://www.huston.com/news/local/hashtastaff/articles/2013/04/24/colleges_worry_about_always_plugged_in_students (discussing Professor Zittrain’s decision to ban laptops). See also Palfrey, supra note 7, at 188 (many Harvard law professors ban classroom laptops); see also DeGriff, supra note 55, at 207 (noting several top law schools, including the Universities of Chicago, Michigan, Virginia, as well as Vanderbilt, have installed mechanisms that allow professors to disable or block Internet access).

245 See Kristen E. Murray, Let Them Use Laptops: Debunking the Assumptions Underlying the Debate over Laptops in the Classroom, 56 ORLA. CITY L. REV. 155, 158-201 (2011); Jeff Severin, Law Student Laptop Use During Class for Non-class Purposes. Temptation or Inevitability, 51 U. LOUISVILLE L. REV. 465, 484-86 (2011); see also Eric D. Ragan et al., Unregulated Use of Laptops on Tone in Large Lecture Classes, 78 COMPUTER & SECURITY 510 (2013) (students who brought laptops to class engaged in off-task activities two-thirds of the time).


247 See J.M. Kessner & David Novak, Examining the Effects of Student Multitasking with Laptops During the Lecture, 21 J. APPL. SCHOL. 241, 248-50 (2010) (study compared student self-reporting of classroom multitasking to data gathered via software which showed they substantially underreported their off-task behavior); see Ravizza et al., supra note 115, at 112 (university students likely underreport their classroom use of wireless devices for off-task activities). In some surveys, however, students have volunteered that they use their laptops for off-task activities most of the time. See Ragan et al., supra note 245, at 81, 84-85. But see Mimi Barak et al., Wireless Laptops as Means for Promoting Active Learning in Large Lecture Halls, 36 J. RES. TECH. EDUC. 245, 247-48, 251 (2008) (students enrolled in computer engineering courses reported favorable experience using laptops in class for interactive exercises); Robin Ray & Sharon Laveau-Chea, Unstructured vs. Structured Use of Laptops in Higher Education, 10 J. INF. TECH. EDUC. 35, 39 (2011) (based on student self-reporting, researchers found off-task use of laptop during class was less than expected).

248 See BROWN ET AL., supra note 178, at 121 (discussing the “Dunning-Kruger effect,” which is the phenomenon that recognizes unskilled students overestimate their abilities); Ping-Yi Fins Wei et al., An Experimental Study of Online Chatting and Notetaking Techniques on College Students’ Cognition Learning from a Lecture, 34 COMPUT. HUM. BEHAV. 148, 149 (2014) (college students do not believe multitasking interferes with learning); Ravizza et al., supra note 115, at 112 (and studies cited therein); Glenn, supra note 109 (students who multitask under the “illusion of competence” that they are performing well).

249 See Kim et al., supra note 266, and supra note 262.

250 See Parra Sana et al., Laptop Multitasking Hinders Classroom Learning for Both Users and Nearby Peers, 62 COMPUTER & SECUR. 34, 29 (2013) (students wanted in view of multitasking peers had impaired comprehension); Emily Gasser et al., Student Laptop Use in the Classroom and Its Impact on Student Learning (May 6, 2013) (unpublished senior thesis, Ethaca State University) (on file with author) (student authored survey found that university students were disrupted during class due to the laptop contamination effect); Clay Shirky, Why Clay Shirky Banned Laptops, Tablets and Phones from His Classroom, MEASURE (Sept. 15, 2014), http://www.npr.org/sections/makeradio/2014/09/why-clay-shirky-banned-laptops-tablets-and-phones-from-his-classroom/ [http://perma.cc/3XXD-87M6]; see also Matt Richtel, Attched to Technology and Paying a Price, N.Y. TIMES (June 6, 2013) http://www.nytimes.com/2013/06/07/technology/html/fbrsamsg.html?pagevariant=all [http://perma.cc/SM4C-R08R] (Professor Shirky refers to this as the “second hand smoke” problem and it is another reason why he decided to ban laptops). But see Aguilar-Roca, supra note 246, at 1306 (study found that students sitting in a re-laptop zone were not disturbed by laptop users though “spreading effect” did increase distraction among laptop users).

251 See Aguilar-Roca, supra note 246, at 1306; Sana et al., supra note 249, at 29.
interactive learning tool and our evolutionary programming, which makes it nearly impossible for the cavernum brain to resist the distractions they cause.251 This is especially true given that many wireless devices and websites are designed to distract users with a barrage of instant notifications, pop-ups, and links tailored to each user’s personal interests.252 Due to the contagion effect, it only takes a few students to succumb to the siren call of Facebook or online shopping to cause a distraction that interferes with the learning of many others.253

The relationship between the ability to pay attention and success in school is well established, as is the one between distractions caused by wireless devices and negative learning outcomes.249 One study tried to quantify the effect that college students who multitask during class could expect their grades to plummet from a “B” to a “D.”250 More eye-popping than that is a recent large-scale study by researchers at Carnegie Mellon who found a “strong” correlation over a four-year period between a high school’s broadband usage and declining student test scores.251 They also found that merely blocking a school’s access to YouTube caused grades to go up.252 And cognitive load theory tells us that multitasking may have an especially deleterious effect on students who are trying to learn new things in particular because of the heavy burden it places on working memory’s limited processing capabilities.253

Those defending classroom laptops argue that technology is not the problem; rather it is boredom professors. If students are missing laptops in class, the argument goes, it is no different than the off-task behaviors of a bygone era when bored students passed notes, read the newspaper, or stared out the window. The solution is not to ban technology but to better engage students. Part II exposes the fallacy of this argument since the cavernum brain is programmed for distractibility and novelty-seeking, which the tech designers fully exploit.

No teacher, no matter how interesting, can simultaneously fight the Darwinian survival imperative served by a distracted brain and the evil minions of Silicon Valley.248 And even if you were “the most interesting man in the world,” it would not help, according to a new study that found distractions interfering with “high interest” lectures have a greater adverse effect on learning than those interfering with “low interest” ones.249 It is because
the former diverts a greater quantum of each student's limited attentional capacity away from learning. Students also overestimate their ability to learn while multitasking so they see no reason to curb their own behavior, meaning we must do it for them.282

Putting laptops in the classroom yet failing to manage their use is tantamount to creating an attractive nuisance that can negatively affect every student's learning. It is why, after allowing laptops for nearly two decades, Internet scholar Professor Clay Shirky of NYU recently decided to ban them, concluding "humans are incapable of ignoring" the distractions they cause.284 And it is why former Harvard Law Professor and author of Born Digital John Palfrey says that "best practices" for classroom technology use in law school is about knowing when to turn it off.285

The reason for putting laptops in the classroom in the first place was the belief they helped inculcate students into the expectations of law practice back in the 1990s when everyone wore flannel and Ally McBeal was still on TV. But by now wireless devices have become so ubiquitous that the rationale no longer applies. In fact, because of their ubiquity, the more pressing need today is to teach students the importance of managing their technology use so they can learn to work better and smarter.286 Thinking like a lawyer will always require the college students polled at six universities said they favor teacher-imposed limitations on laptop use.

282 See POWERS, supra note 5, at 76-77 (Google's CEO tells college students "turn off your computers" and "just disconnect" because it is not healthy to be plugged in all the time); Simon Baron-Cohen, A Thousand Hours a Year, in 18 THE INTERNET CHANGING THE WAY YOU THINK?, supra note 3, at 173, 174 (persistent, frequent email threats exact capacity for real work—we need to restrict it to certain times of the day).

283 See GALLAGHER, supra note 76, at 10, 67 (mentioning "laptop" is a skill which, like any other, takes effort and practice to develop). POWERS, supra note 5, at 102 (in an always-connected world, the need to unplug and recharge is more urgent than ever); Baron-Cohen, supra note 207, at 174; Palfrey, supra note 7, at 114 (we must teach students to unlearn unproductive behaviors resulting from excessive technology use).


285 See Carey, supra note 7, at 34; MEIZINGA, supra note 67, at 235 (stating that the more prior training the sensory input, the more likely it will be remembered and recalled); supra pp. 375-76 and accompanying notes.
that we should pick methods and tools based on their compatibility with our classroom objectives, not what is most familiar or popular with students. The subject matter we teach is complex and often does not lend itself to easy explanations, pictures, or bullet points. If we sacrifice complexity and nuance for the sake of fitting the material onto a slide, we risk enabling lazy System 1 thinking instead of helping students build the intellectual muscles needed for System 2.

Critics of visual technologies like Professor Edward Tufte of Yale, a leading scholar on visual literacy, argue that PowerPoint undermines analytical thinking for these very reasons. Others argue that “PowerPoint is quintessentially designed for one-off,” shallow reading rather than deep engagement. Sure, students can download and study the slides later, but how many really do, and can a slide engage students like print, which they can attack with pen and highlighter in hand? There is also the temptation to oversell the tools to meet the expectations of students who may have grown accustomed to them as undergraduates.

With those important caveats in mind, pictures can in fact be very effective teaching tools precisely because the brain is so visually oriented. But we need a strategy for deciding whether they are the best ones for the job to avoid the aforementioned risks. The best place to start is by asking whether a visual can adequately communicate the material in all its complexity and nuance compared to the alternatives. Related to that, we should ask whether a visual modality promotes the effortful engagement required by System 2 thinking rather than reinforcing facile caveman thinking. Remember too that pictures are often ambiguous, which is why they need captions, so we need to consider whether the ones we plan to use communicate the ideas with precision and clarity.

To take an example from my own teaching, I use a visual to explain to my 11a the concept of inferential thinking because I believe it works better than the alternatives. I show students a picture of footprints in the sand and then ask whether we can all agree that someone was recently walking there, even though we never saw them nor do we have any eyewitnesses to ask. They instantly “get it” because the visual explains the idea more succinctly and clearly than I can with words.

In perhaps the definitive article on using PowerPoint in law school, Professor Deborah J. Merritt describes a torts class in which she teaches battery by showing students a picture of one child kicking another to illustrate the facts of Vosburg v. Putney. She explains that a well-chosen visual embodying all elements of a claim can work as a chunking technique to help
students process a larger volume of information that might otherwise overwhelm working memory. An added benefit is that a visual can provide a vivid, memorable reference point to anchor further class discussion about any of the issues later in the semester.

Assuming a visual is compatible with the teacher’s objectives, the next step is to pick images that are both memorable and meaningful. The importance of using memorable visuals is obvious enough, but they should also be meaningful insofar as they serve as a familiar reference point for students. This will help students connect the material to their existing schemas. Thus, meaningful images can deepen understanding while those that merely grab attention may be counterproductive if they overshadow the underlying point.

Next, designing good visuals is about keeping them simple. PowerPoint comes with lots of special effects like sounds and animation that can liven up a slideshow while also turning it into a multimodal learning tool. However, students say they get distracted by special effects unrelated to the content of the slides. And using too many special effects may also overwhelm working memory such that the underlying point is lost.

287 See Merritt, supra note 281, at 51–52; supra pp. 259–60 and notes 110–12.
288 Merritt, supra note 281, at 53; see also Carey, supra note 7, at 34 (stating that the human brain’s recall for images is strong).
289 Merritt, supra note 281, at 58; see also Carey, supra note 7, at 34; Krajewski, supra note 71, at 259–260 (because the brain is an visually oriented, it makes images highly accessible).
290 Merritt, supra note 261, at 50; see also Medina, supra note 67, at 114–15; supra p. 250 and note 72; supra pp. 258–59 and accompanying notes.
292 Merritt, supra note 281, at 56; see also Jean-Luc Doumen, The Cognition Style of PowerPoint Slides Are Not All Evil, 59 TECH. COMM. 64, 68 (2003) (PowerPoint slides are often ineffective because they contain unnecessary clip art, sounds, colors, and other “reanimations” that is unrelated to the content).
293 See Merritt, supra note 281, at 47 (detailing several experiments that show students who simultaneously process information through visual and auditory channels learn better than those who process it only visually); supra p. 259 and note 100.
294 See Jennifer M. Anderson et al., An Assessment of Student Preferences for PowerPoint Presentation Structure in Undergraduate Courses, 69 COMPUTER & EDUC. 248, 152 (2009) (citing a survey of college students that found they like well-organized, narrated slides when compared with slide content but otherwise found them distracting).
295 Merritt, supra note 281, at 56; see Apperson et al., supra note 289, at 153; Doumen, supra note 287, at 68.
and download later packs all the dynamism of watching paint dry. In fact, it can put heavy-eyed law students to sleep. Professor Merritt points out that when the lights are down low and all eyes are focused on the screen, student-teacher interaction grinds to a halt. Not surprisingly, some college students say PowerPoint turns them into passive observers who are less likely to interrupt the teacher to ask questions.

For all these reasons, never overlook the whiteboard as a better alternative. Just as PowerPoint can feel scripted and stiff, using the whiteboard more closely follows the natural rhythm of a conversation between teacher and students. A “chalk-talk” is also a multimodal learning experience because even watching physical activity like a teacher writing on the board is processed by the brain differently than looking at slides. The former creates motor memories in addition to visual ones, which experts say may enhance retention and recall. It is consistent with surveys finding that students learn better and are more engaged watching a “chalk-talk” than PowerPoint. If nothing else, using

(see El Khoury & Mattar, supra note 275, at 242 (noting surveys that God students are less likely to take notes, and more likely to sleep, if they know they can review slides later)); see also Swasow et al., supra note 275, at 239.

302. See also Douglas L. Leele, How Not to Teach Contracts, and Any Other Course: PowerPoint, Laptops, and the Casual Method, 44 St. Louis U. L.J. 1299, 1299 (2010) (laptops and PowerPoint in law school). See also supra note 275, at 242. Swasow et al., supra note 275, at 239. But see Aiperson, supra note 289, at 155 (collage students said they like the teacher to do the board because they can see the slides better).

303. See El Khoury & Mattar, supra note 275, at 242; see also Emerling, supra note 9 (it is tech-obsessed again, teachers often favor traditional chalkboards even visual aids because research shows it is a modality that is better suited to certain subject matter, like math). See Anne Manon & Jean-Luc Velty, Digitalizing Literacy: Reflections on the Effects of Writing, in ADVANCES IN HAP 345, 360, 364 (Mehmet Hamdi Zaldak ed., 2010) [hereinafter Manon & Velty, Digitalizing Literacy]; Trend Guide Top, Better Learning Through Handwriting, SCHOOLDAD (Jan. 24, 2011), http://www.schooldad.com/reviews/2011/01/24/1905165.html [https://perma.cc/D6Y9-375P] (imagery research shows merely watching physical activity lights up areas of the brain associated with sensorimotor function, meaning the information is processed both visually and physically, sensorly data leaving both kinds of neurons).

304. See Manon & Velty, Digitalizing Literacy, supra note 302, at 394, 396, supra note 302.

305. See El Khoury & Mattar, supra note 275, at 252 (noting a survey of foreign university students); Natsum Hashimoto & Loreta Wilson, Teaching with the Lights Out: Help in Teaching: Interactive Instruction, 21 C. STUDENT J. 601, 608, 611 (2007) (analyzing a survey of U.S. college students); Swasow et al., supra note 275, at 241 (noting that foreign university students say a chalk-talk has greater immediacy than looking at the screen in a darkened room); Krishna T. Yamishi et al., Comparative Study on the Teaching Effectiveness of Chalk & Talk and Microsoft PowerPoint Presentation from the Student Perspective, INT’L J. PHARMACY & PHARMACEUTICAL SCI. (JULY–AUG. 2011), at 1, 92 (containing a survey of foreign university students); see also Emerling, supra note 9.

306. See El Khoury & Mattar, supra note 275, at 242; supra p. 289 and note 297.

307. See Bower, supra note 11, at 387–89; Lylese Layton & Elana Brown, SAT Reading Scores Hit a Record Pace in 2012, WASH. POST (Sept. 24, 2013), http://www.washingtonpost.com/local/education/2012-sat-reading-score-hit-a-four-decade-low/2012/09/24/4e7c86c6-54de.scholar?utm_source=wp/The/0423013340401440147 (noting the new SAT’s reading section is longer and more difficult). The only technology issue this raises is whether to emphasize screens, print, or a combination of the two. The term “digital native” suggests this is a nonstarter since today’s students supposedly only read electronic media and consider print an antiquated format they won’t go near. Like other assumptions about digital natives, this may be more chichi than fact.

Numerous polls of university students find that the majority still prefers print for schoolwork believing it helps them learn better. Even surveys of tech-savvy teens show that some like
print more than their parents. Only a short time ago it seemed certain e-books would do to print what the mp3 did to the music industry, yet sales have already plateaued or even declined, some sources believe. Technology stars like Bill Gates prefer print for deep reading, and Steve Jobs refused to let his own children use an iPAD to read. Silicon Valley top executives send their kids to a private school where print is king and computers are banned. And many people who read and think for a living, like

outperform those reading screens on tests that measure both comprehension and retention.114 In some cases, the differences were significant.115 Some experts characterize the difference as the those who read print understand what they have read, while those reading screens merely remember it.116

Other studies find that print is a more immersive experience compared to screens and even dedicated e-reading devices.117

Implications of New Media, in THE JOHN HOPKINS GUIDE TO DIGITAL MEDIA 72, 75 (Marie-Laure Ryan et al. eds., 2014). Further, some of these studies found no differences in the formats by relying on students' final course grades as a proxy for learning rather than more objective forms of assessment or evaluation.

In comparison, Professor Mengen, one of the leading authorities on reading technologies, has studied the differences between print and screens on learning using larger, more substantive tests that may be closer to approximating the reading assignments used in law school. See Mengen & Kuenen, supra note 3 at 157, 164-67 (finding print has cognitive advantages compared to screens when subjects tested on 10 easy and 10 advanced story plots (literary short stories); Almos Ford, Readers or Readers on Kindles than on Paper, Study Finds, GARDIAN (Aug. 19, 2010), http://www.theguardian.com/books/2010/aug/19/kindle-absorb-loss-kindles-paper-study-reader-digitization [http://perma.cc/8RSA-NOX7] (reporting on research by Professor Mengen finding that print has cognitive advantages compared to screens when subjects were tested on a twenty-eight page mystery story).118

114 See BARON, supra note 274, at 83, 170-71, 217; Ackerman & Lanterner, supra note 313, at 1028 (print has metacognitive advantage over screens leading to better comprehension and retention); Mengen et al., supra note 313; Tannor, supra note 307, at 4-5 (scoo, supra note 313). (reporting results of 2014 study finding print performed better than Kindle readers when tested on recall of a twenty-eight page story); Jahn, supra note 322 (reading print is better than e-readers because reading print may be more conducive to metacognition). See also FORAN, supra note 313, at 31 (finding no difference between formats when students tested on “simple, familiar, or low-stakes” reading. See also MARQUET et al., supra note 313, at 314, 317-18 (discovering no differences in reading comprehension across when students tested on ten short passages); Amaida J. Bockning-Stanek et al., ELECTRONIC Versus TRADITIONAL Print TEXTBOOKS: A COMPARISON Study of INFLUENCES of UNIVERSITY Students’ LEARNING, 36 COMPUTER & EDUC. 209, 393 (2014) (comparing physical print and e-textbooks for a single course, with no significant difference in comprehension scores).

115 In comparison, Mengen et al., supra note 313; Chen et al., supra note 314, at 220, 222. See also Jordan T. Schugart et al., A Node or a Book?: Comparing College Students’ Comprehension Levels, Critical Reading, and Study Skills, 7 INT’L J. TEACHING & LEARNING 174, 185-84 (2013) (finding in a study of freshmen university students there was no difference in comprehension and recall scores between e-readers and print, but researchers acknowledged overall student test results reflected poor aptitude, a general failure to critically evaluate the reading, and low motivation towards reading. See also, supra note 314).


117 See BARON, supra note 274, at 162, 168-70 (summarizing studies); Mengen et al., supra note 313, at 67; Mengen & Kuenen, supra note 4, at 160, 160-63 (studying university students reading a non-fiction story in print format versus on an iPad and finding that they had more narrative coherence, transportation, and sympathy when using the former i-device).

118 See BARON, supra note 274, at 149, 213; Mengen & Kuenen, supra note 4, at 163 (being transported by a fictional or nonfictional narrative means a reader is more immersed in i-Device). See also, supra note 313, at 162-66 (2014 study by Professor Mengen); cf. Mengen & Kuenen, supra note 4, at 162-66; Jahn, supra note 307.

119 See BARON, supra note 274, at 82-83, 100; de Groot, supra note 313 (citing a study which found that screen readers take short cuts); Jahn, supra noe note 307, at 23 (stating that students say they study and learn more reading print than screens); Reynolds-Jones & Chandrarama, CHEN, Predicting Course Outcomes with Digital Textbook Usage Data, 27 INTERACTIVE & ELECTRONIC EDUC. 94, 95 (2015) (discussing research showing that university students spend little time reading their digital textbooks). This is a highly significant point given a recent study finding that the amount of time students spend engaged in their class reading assignments may be the best predictor of course outcomes, even more so than their grade point. See Reynolds-Jones & Chandrarama, supra, at 57-58 (discussing a study analyzing student reading practices using data from a CourseSmart e-textbook, the first commercially available product to offer user reading analytics). See also, supra note 313, at 85-86, 128; de Groot, supra note 312, Jahn, supra note 307, 31, 23.

120 See Mengen et al., supra note 313, at 90. Flood, supra note 213 (the haptic characteristics of a Kindle do not support the same mental reconstruction of a story’s chronology as print); Andrew Pipp, Out of Touch: e-Reading Isn’t Reading, SLATE (Nov. 15, 2012), 522 AMA, http://www.slate.com/articles/technology/online/2012/11/reading_on_a_kindle_is_not_the_same_as_reading_a_book_single.html [http://perma.cc/2B4J-Q6XM] ("touch isn’t only a matter of our brains; it’s something that we do with our bodies.")

121 See Mengen et al., supra note 313, at 62, 66-67 (even comparing visual characteristics, screens are still inferior to print); Jahn, supra note 307 (despite the name "touch screen"- e-text is ephemeral and lacks the tactile qualities of print).

122 Mengen & Velzy, supra note 313, at 74-76; Flood, supra note 313; Jahn, supra note 307.
The field of educational haptics, which examines how touch affects cognition and learning, has been largely overlooked by learning scientists.232 In fact, touch has been shown to play a major role in learning, in some contexts more than vision.233 Touch is the only sense that interacts with the physical world, and can even manipulate or change it, in comparison to passive senses like hearing and vision.234 Haptics relates to the theory of embodied cognition by recognizing a mind-body connection in all cognitive activity leading some experts to advise that teaching tools incorporating physical characteristics, like books, can promote deeper engagement and understanding than purely visual ones.235

Haptics explains why books provide the reader with a better sense of chronology and organization than screens because they afford both a physical and visual sense of moving through the story.236 This creates sensorimotor memories in addition to visual ones that may enhance understanding compared to a screen.237 The physicality of books may also activate ancient brain circuitry devoted to language from the time when our ancestors communicated via gestures.238 Thus, the cavernan brain may process print in ways that connect it to language, which improves retention and recall making it a completely different experience than reading a screen.239

121 Mussen & Velay, supra note 302, at 302; Minassian & Jones, supra note 354, at 317-19, 329.
122 See BARTON, supra note 76, at 180 (extensive links exist between physical movement and learning); SYNEVEER, supra note 40, at 56-57 (stating that the skin is where the brain meets the outside world); WILSON, supra note 224, at 286, 289; Mussen & Velay, supra note 302, at 394-95; Minassian & Jones, supra note 354, at 317-13, 325, 331-32 (showing that haptic is superior to vision in some contexts and is involved in all learning).
123 Minassian & Jones, supra note 354, at 318.
124 See WILSON, supra note 224, at 286, 289; Mussen & Velay, supra note 302, at 392-95; Minassian & Jones, supra note 354, paragraphs (including haptic considerations in teaching methodologies can improve learning); see also TANNER, supra note 391, at 9; Flood, supra note 313, Jaber, supra note 307.
125 BARTON, supra note 274, at 179; Mussen et al., supra note 313, at 60; De Groot, supra note 313; Flood, supra note 313; Jaber, supra note 367.
126 Anne Mussen & Thomas R. Schilbahn, An Embodied View of Reading: Theoretical Conceptions, Empirical Findings, and Educational Implications, in TEXTS Last 293, 295-99 (Symposium Maire & Alt Shafourn eds., 2010) (finding that our physical, sensorimotor interactions with a book are irelevant to the way we interact with traditional print books); Mussen & Velay, supra note 302, at 392-95. See generally Mussen & Jones, supra note 354.
127 See HILLHOUSE, supra note 312; see also BARTON, supra note 76, at 180, 270, 275, supra note 224, at 58 (citing studies where researchers tested children learning to write and found a relationship between the ability writing and brain activity related to language); supra p. 176 and accompanying notes.
128 See HILLHOUSE, supra note 312; supra note 310-14.

Print is also a more immersive experience because it lacks the distractions of electronic media such as hyperlinks and email that pull the reader away from the text.240 One neuroscientist leading a "slow reading" movement says that because of this, reading a book for just thirty to forty-five minutes a day can restore the loss of attentional abilities due to digital devices.241 That alone is reason enough to emphasize print more often as a training tool to help students strengthen these key skills. Apart from the haptic advantages, some experts believe that the greater visual focus, concentration, and eye-hand coordination needed to highlight, write margin notes, and turn pages are further reasons why books engage us as a visual medium more so than screens.242

This is not to say we should eliminate electronic text from the classroom, as if that were even feasible. To the contrary, screens are the best, most efficient tools for reviewing large volumes of material quickly, such as when doing legal research. E-books in particular also have great potential to provide analytical data on student reading practices that could help inform our teaching, course design, and predict learning outcomes.243 On the other hand, going paperless is not a good classroom strategy either given print's superiority as a reading medium. And despite initial predictions to the contrary, it is unlikely print is going to disappear anytime soon.244 For all these reasons, this Article recommends adopting the same hybrid reading style used by other professional readers by emphasizing...
print for deep reading and screens for everything else. It is a strategy that will also help students develop better media literacy through an understanding of different forms and the advantages and disadvantages of each.

E. "That’s Not Writing, That’s Typing"

Like reading technologies, the only issue here is whether to encourage the use of laptops or pen and paper for note-taking and other writing tasks. Common sense says students cannot write as fast as they type, so having them take notes by hand forces them to slow down and become more selective in what they record. In theory this should help students focus on better understanding the material because out of necessity they will need to summarize it in their own words. One learning expert takes this to the extreme by forbidding students in his class from taking any notes at all in the belief that they will learn more by devoting their full attention to the discussion rather than splitting it between listening and writing. 241

The prevailing assumption about students using laptops to take class notes is that they mindlessly type away trying to capture the teacher’s every word. Thus, they listen for accuracy like a stenographer instead of understanding. On the other hand, perhaps laptop-savvy students take better quality notes than we think. And if they prefer to use a laptop, who are we to judge?

Research on note-taking styles is still emerging and, therefore, limited, but so far it supports the view that taking notes by hand improves learning compared to using a laptop. 242

240 See Baron, supra note 274, at 223-28.
242 See Magen & Velay, supra note 303, at 309; Toff, supra note 302.
243 See Glenn, supra note 109.
244 See Pam A. Mueller & Daniel M. Oppenheimer, The Pen Is Mightier than the Keyboard: Advantages of Longhand over LaptopNote Taking, 25 PSYCHOL SCI. 1199 (2014) (noting that studies show most students type significantly faster than they write using laptops but users facilitate a transcription-like note-taking style, cf. Keim, supra note 226, at 85 (stating that the text manipulation powers of a word processor could aid complex thought and its speed might feel to some more true to the mind than writing by hand); see Magen & Velay, supra note 313, at 76 (summarizing studies involving children that compare typing versus writing while acknowledging that research is still sparse); Mueller & Oppenheimer, supra note 342, at 1149; Hansh Shahfer, Effects of Note-taking Style on Paper Versus Computer Based Reasoning Comprehension, RED RIVER PRESS, J., 6-6 (2008), http://www.redriverpsychology.com/red_river Psychology_Journal/1Hshfehr2011.pdf [http://perma.cc/MDY3-Z5YV] (college students had higher test scores when they read and wrote answers on paper compared to computers); Timothy J. Stromer et al., Comparing Memory for Handwriting Versus Typing, 2016 Teaching the Digital Caveman 299

As a preliminary matter, researchers have found that note-taking style correlates with academic success. Among all students using laptops, those who transcribe class discussion do more poorly on tests measuring conceptual understanding than those employing a more selective note-taking style. 245 Research also shows that the majority of laptop users default to the less effective transcribing style even after the teacher warns them against it and explains why. 246 Thus, even when students use laptops for their intended purpose rather than multitask, they have a delusional effect on learning by encouraging a counterproductive note-taking style. 247

By comparison, studies show that the physical act of writing things down, like making “to do” lists, enhances memory. 248 Another study found students who take notes by hand had better comprehension and recall than laptop users. 249 Even when both

Typing, PROC. HUM. FACTORS & ERGONOMICS ANNUAL MEETING, OAH, 2009, at 1744, 1746, http://cechert.org/boards.wiley.com/uploads/594/20614577/comparing_memory_for_handwriting versus_typing.pdf [http://perma.cc/65QG-6R2U] (recall and recognition of words were better for those writing by hand compared to typing); Tiffany O’Callaghan, The Writings on the Screen, NEW SCIENTIST, at 43 (Nov. 1, 2010), http://www.new scientist.com/article/mg22429360.500-goodbye-paper-what-we-see-when-we-read-on-screen.html (separate studies have found learning is enhanced in both young children and adults when we write things down by hand because doing so recruits brain circuits devoted to physical movement which seems to enhance memory).

245 See Matthew R. Barrett et al., Technology in Note Taking and Assessment: The Effects of Cognition on Student Performance, 100 J. EDUC. RES. 298, 309, 312 (2017) [hereinafter Magen et al., Handwriting Versus Keyboard Writing] (containing a study comparing word recall and recognition between college students writing words down by hand, typing them on a laptop, and using a tablet that partly replicated Smoker’s study, supra, by finding that handwriting improved recall though no differences were found in word recognition).
246 See Barrett et al., supra note 245, at 148, 153 (citations therein); Toff, supra note 302.
247 See Mueller & Oppenheimer, supra note 342, at 1162, 1166 (verbatim note-taking style correlates with shallow understanding).
248 See id. at 1162-63, 1167.
249 See id. at 1166.
251 See Mueller & Oppenheimer, supra note 342, at 1166 (stating that research found students taking notes by hand have better recall of facts than laptop users when there is a delay between the lesson and follow-up testing, but no difference when testing is done immediately afterwards); see Aparicio-Bos et al., supra note 246, at 1304 (finding that students who took notes by hand had a “significantly” higher number of “A’s” than laptop users); Magen et al., Handwriting Versus Keyboard Writing, supra note 343, at 512; Shulman et al., supra note 313, at 21-22 (finding that students at a large California university who took notes by hand produced better written reports that
groups reviewed their notes a week later before a follow-up test, students who took notes by hand had better conceptual understanding and even superior factual recall compared to those who took “verbatim”-style notes on their laptops.\textsuperscript{303} In yet another study, college students taking notes by hand had "significantly" better on a final exam, including earning more As, than those using laptops.\textsuperscript{301} The researchers found this particularly surprising since the SAT® scores of the laptop users predicted they would outperform the other group.\textsuperscript{302}

The explanation for all these results is much the same as those used to explain the cognitive advantages of print over e-text.\textsuperscript{205} Just like books, writing by hand is a multimodal learning experience that engages brain circuitry devoted to both visual and physical processing.\textsuperscript{204} Typing also has multimodal characteristics, but writing takes greater eye-hand coordination since students must, in effect, draw the shape of each letter.\textsuperscript{205} And because writing requires greater focus and concentration

than typing, it may even promote more precision in the expression of thought in addition to deeper engagement.\textsuperscript{306} The greater physicality of writing appears to promote linkages in the brain between visual, tactile, motor, and spatial neural circuits, which means it is processed differently than typing in ways that seem to enhance recall and comprehension.\textsuperscript{307}

While typing is a physical act too, some aspects of it are decoupled from the visual part, making it a "radically" different cognitive experience than writing by hand.\textsuperscript{308} Even the visual aspects of writing by hand require more engagement and concentration than typing which eventually becomes so automated that students can do it without even looking at the keypad or screen.\textsuperscript{309} As with print, pen and paper also promote deeper engagement, and thus better learning, because the medium lacks the interferences and distractions associated with wireless devices.\textsuperscript{310}

That taking notes by hand has demonstrable advantages over typing on a laptop has been suggested as reason enough to ban laptops.\textsuperscript{311} But if the teacher is making good use of them in class, to the extent student notes suffer it may still be an acceptable trade-off. If the professor is not making active use of laptops during class, they should be closed anyway which is a great opportunity to talk with students about the advantages of adopting a hybrid note-taking and drafting style. Share with students the research discussed here that taking notes by hand

\textsuperscript{205} Writing by hand is like "thinking with a pencil." Mengen & Velyk, supra note 311, at 75 (noting that draftsmen practiced in the use of CAD software still draw preliminary sketches by hand because it is "thinking with a pencil"); see also Wilson, supra note 82, at 158 (writing and drawing are strongly related to other skills required prospecting); WOLK, supra note 5, at 60-66 (stating that the process of writing changes our thoughts and helps us express them with more precision); Keim, supra note 224, at 56 (citing an educational psychologist who notes that we use our hands to access our thoughts).

\textsuperscript{206} See BIKO, supra note 274, at 143-49. Mengen & Velyk, supra note 302, at 380-90. Experts also believe an advantage of writing by hand is that it engages spatial circuitry in the brain which encodes the location of words and paragraphs on the page, providing a structure and organization for our thoughts that is lacking when we type on a screen. Keim, supra note 224, at 56 ("What our hands do with a keyboard is very different than with pen and paper."); Toft, supra note 302.

\textsuperscript{207} See the Mengen & Velyk, supra note 302, at 380-90; Keim, supra note 224, at 56 (stating that a central property of handwriting is that it unifies hand, eye, and attention at a single place and time in the brain).

\textsuperscript{208} See POWERS, supra note 8, at 216; Wei et al., supra note 248, at 148, 155 (finding that students using laptops to take notes while multitasking had poor quality class notes and lower recall of the material).

can improve memory and comprehension, which is why even Silicon Valley technologists prefer pen and paper to note-taking apps. It is consistent as well with surveys of college students that show some still prefer a pen and paper to the keyboard for the same reasons. When it comes to drafting, encourage students to experiment with each writing technology while reflecting on how it affects the writing process. As a metacognitive exercise, some students may discover they do their best work composing on a keyboard while editing with a pen and paper instead as it helps them better visualize how all the pieces fit together. Others may find that outlining by hand sharpens their analysis and organization in ways that a keyboard does not. As with reading technologies, the key thing is to put aside clichés about how “digital natives” learn best and instead help students understand the importance of choosing the right tool for the job based on what works best for them and its compatibility with the particular objective at hand.

As a practice skill, there are times when lawyers need to put away technology and pick up a pen and pad of paper instead. In depositions, interviews, and similar situations lawyers must be fully present to observe and record their impressions of the other person in the room. In other contexts, like meetings with clients and partners, putting away technology in favor of pen and paper can communicate engagement, rapport, and warmth. The caveman brain was designed to excel at these so-called “soft skills” which, ironically, may become increasingly important as they may be one of the few legal practices that remains beyond the reach of the lawyer-bots. Encouraging students to develop a hybrid note-taking style, therefore, promotes not only better learning and media literacy, but also gives students a chance to practice some other essential lawyering skills.

F. “Survey Says”: Meta-Analysis of Digital Teaching Tools

Two recently published meta-studies are among the largest to date assessing the overall effectiveness of digital teaching technologies. They did so by examining the impact of these tools on student learning outcomes in a variety of classroom contexts from kindergarten to post-graduate training. Though neither study focused on specific classroom tools like laptops, they are still valuable insofar as having distilled data from thousands of independent studies into some general principles and guidelines that we can use to help inform our own decisions about how best to use technology in the law school classroom.

The first of these studies is a meta-analysis commissioned by the U.S. Department of Education (“DOE Study”) in 2010 that reviewed more than 1,100 independent studies conducted between 1996 and 2008 for reliable data on the effectiveness of online instructional tools. The second study was published in 2012 by Durham University in the U.K. (“Durham Study”) involving an analysis of forty-eight separate meta-studies from
around the globe that examined the general effectiveness of digital classroom tools in K–12 schools.372

In sum, the DOE Study found that online tools work best when combined with face-to-face classroom teaching as part of a hybrid approach to instruction.373 To the extent any correlation was found between the use of technology and better learning outcomes, the study's authors cautioned against attributing it to the technology itself rather than the extra hours of instruction students received in the blended programs.374 The Durham Study reached a similar conclusion with respect to digital classroom tools finding that they generally work best when supplementing existing teaching practices rather than replacing them.375 The authors of the Durham Study also cautioned against assuming a causal connection between classroom technology and better learning outcomes because of methodological problems with the underlying studies.376 Consequently, both meta-studies came to the unremarkable conclusion that although technology may help, it is ultimately the teacher using it that matters most to student success.377

Nonetheless, the authors of each study identified a few teaching practices they found to be especially effective. For instance, the DOE Study concluded that instructor-led and collaborative online learning opportunities often worked better than independent, self-directed ones.378 Technologies that let students control the pace of their own learning like podcasts also worked well, as did ones that encouraged students to monitor their learning.379 The authors of the Durham Study found the use of digital technologies that promote collaborative learning among small groups of students are effective along with tools that extend learning opportunities outside classroom walls like video simulations.380

While none of these conclusions are especially earth-shattering given what we already know about good pedagogy, they tend to confirm the work of educational technology historians like Professor Cohen by finding that digital technologies are most effective when combined with established teaching practices as part of a hybrid approach to classroom instruction.381

CONCLUSION

The term "digital native" is misleading because it suggests a sharp divide between today's law students and their predecessors. It encourages inaccurate stereotypes and clichés that can have a detrimental effect on their legal education. The erroneous belief that all students are tech savvy, for instance, means we may mistakenly jump to the conclusion that it is unnecessary to provide training in basic technology skills. The assumption that multitasking is part of a new "learning style" means we may neglect to teach students the important mental discipline needed to single-task.

This Article argues that classroom practices informed by an understanding of how the brain learns will always be more successful than approaches based on observations about students' changing technology habits. Technology and forms of media are always changing, but the fundamentals of teaching students to be good critical thinkers have not changed much at all over time. Whether writing an appellate brief, synthesizing a line of cases, or solving a complex problem for a client, it will always demand an ability to shut out distractions and focus deeply on that task at hand.

Of course we need to prepare students to work in a digital environment. But teaching them how to use the latest law practice app will never get them a job—anyone can learn to do that. Teaching them, instead, to be good thinkers is the gift that keeps on giving. To maximize our effectiveness as teachers, history and learning science both tell us that the most successful strategy is a hybrid approach that combines the best of established classroom practices with new technologies that fill a niche better than existing options.