Medium Matters for Reading
What We Know about Learning with Print and Digital Screens

A Report for K-12 Educators

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Reading lies at the heart of education. Whether we inscribe words on waxed tablets, sheepskin, paper, or electronically, we rely on writing to convey information, share our thinking, and inspire ourselves and others. As the digital revolution gained steam, schools began shifting the balance of learning materials from mostly print to more onscreen reading. Then COVID-19 struck. Schooling had to go virtual, which also meant a sharper tilt to reading digitally.

Does the medium on which students read matter? Researchers have been actively exploring this question for more than a decade. We now have a fairly clear understanding of the pros and cons of print versus screens for learning. Awareness of these findings is especially critical as we work to re-center curricular thinking after more than a year of educational disruption.

An abundance of research now substantiates that yes, medium matters for learning. While both print and digital have roles to play, the evidence demonstrates the continuing importance of print for sustained, mindful reading, which is critical to the educational process.

This Report is designed for K-12 educators who make decisions about the reading materials students use – or who need to deal with selections made by others. A fair warning before we begin: research on learning can be messy. Not all studies reach the same conclusions. And remember that readers have individual tastes and preferences. Some people are bookworms, others not. Some enjoy reading digitally, others don't. At times these choices can influence performance in formal testing.

We also need to keep in mind that both print and digital media have virtues, including for learning. This Report focuses on formal research findings that compare the

two media for reading linear text of at least several hundred words. However, there are multiple contexts in which digital learning materials can have advantages over print, including accessibility, convenience, online access to current or reference information, video and audio possibilities, and individualized practice and assessment.[1] There are also effective online tools that foster shared annotation and discussion among students of what they are reading digitally.[2]

Most of what we've learned about reading in different media has come from studying young adults, typically in college. There is, though, growing research on children in middle school and high school (less for lower school). Many of the differences between reading in print versus with screens holds across the age spectrum.

Here I'll be focusing on the most solid findings from researchers around the world. Included in the mix are results from studies I have done with my colleagues. Much of the research I'll be presenting appears in greater detail in my book *How We Read Now: Strategic Choices for Print, Screen, and Audio*. At the end of this Report, you'll find suggested **Questions for Students about Print and Digital Reading**, several helpful **Resources**, a **Notes** section that briefly identifies sources for the research we'll be talking about, and then the fuller list of **References**. Throughout the Report are observations made by students themselves (mostly secondary school and college) about print or screen reading.

Let's begin!

What Makes Print and Digital Screens Different?

People ask if the "container" that words live in – a printed page or text on a screen – really matters. Isn't the "content" – the words themselves – the same? As we think about the container versus content question, let's start by exploring what makes the formats different, including how we interact with them.

Our Senses

First, touch. You hold a book or magazine or newspaper differently from holding (or looking at) a mobile phone, tablet, or laptop. Think as well about how various kinds of

paper feel. That sensation individualizes the reading experience. Also, think about the act of turning physical pages.

Students tell us they connect the sensation of paper in their hands to their mental engagement with what they are reading. Here are the kinds of things they say:

> "*I can feel the paper in my hands and just the touch and feel of it makes me focus more."*
>
> *"[I like] the feeling of turning each page and anticipating what's to happen next."*
>
> *"I really like the texture of books, and I feel like I remember more about the story when it's in print."*

What about touch and digital devices? There are touchscreens and real or virtual keyboards. Regardless of the content you're reading, those screens and keyboards feel the same. To move through the text, you page down (or swipe) or scroll. There's evidence that paging down makes for better comprehension than scrolling.[3] Scrolling offers no markers of beginnings or endings, while the confines of a defined page – even one that's virtual – give readers a sense of both context and geographic place.

Which brings us to sight. With printed books, think about the times you've located something you read earlier by using visual landmarks: about halfway through the book, on the righthand side, near the top. Digital reading lacks these landmarks. The difference has implications for our reading. Research with both preschool children and young adults suggests that readers (including those being read to) are better at remembering when and where in a story an event takes place when they're using print, which has a tangible, visual order to it.[4]

Sight is also relevant when you're using multiple texts – something we likely did with bound volumes when writing research papers and that today's children often do with online assignments. Printed sources tend to look (and feel) different from one another. With digital, outside of variation in type font or layout, the materials all look similar.

> "What I like the most about hard copy is that my spatial memory works best, so I remember material by where it was."

To be fair, not all print works the same way. There are actual books (or newspapers and so on) and then there are printouts of online documents. These printouts are "print",

but not the same as originals, which vary in look, size, and feel. A study with university students showed that when they used authentic documents rather than printouts with the same content, their essays had more specifics, incorporated more information about their sources, and were more coherent.[5]

Then there's smell, which a surprising number of readers (not just older adults) notice about print. In my own research, a large number of college students reported that what they liked most about reading print was the smell of books.[6] It's an aesthetic judgment, not one directly affecting how we read content. But it's definitely part of the print reading experience that doesn't have a digital analogue.

"[*I like] the smell of paper and printer ink."*

Convenience and Cost

Many factors shape the decisions that schools make in selecting learning materials. Two of these are convenience and cost. Start with convenience. Using digital reading materials means that, in principle, students have them readily available. However, during the pandemic, we learned how challenging it was for many students to get access to digital devices or reliable internet.

As for cost, most of the time (though not always), digital versions of books are less expensive than print. In K-12, when school systems rather than individual students are generally footing the bill, cost can understandably still loom large. At the college level, cost has been a major reason for the ongoing shift from print to digital textbooks. Open educational resources, which are overwhelmingly digital, can further reduce expenses at all levels.

Yet educators need to balance cost and convenience with learning. Let's see what studies show about student learning in the two media.

Questions Researchers Ask

Researchers have approached the learning question from multiple angles. Here's how I've organized the types of studies we'll be looking at:

Experimental Questions

Reading comprehension with a single text

- Using multiple texts
- Standardized Testing Issues
  - Testing format: paper or screen
  - NAEP ("The Nation's Report Card")
- What Do Students Think?
  - Perception studies
  - "Calibration" issues
- More Aspects of Reading
  - Effort
  - Speed
  - Annotation
  - Reading for pleasure
- What About Other Media?
  - Audio
  - Video

I'll explain each category as we go.

Experimental Questions

Reading Comprehension with a Single Text

Most of the research on reading medium has involved asking students to read a passage and then testing their comprehension. The setup is similar to parts of the verbal sections of college entrance tests such as the SAT. When these studies began about a dozen years ago (almost always with adults), results when reading in print and when using a digital screen often were largely the same, though most participants reported thinking they had done better with print.[7]

More recently, a lot has changed. For one thing, we now have information from a wider age range of readers. Second, researchers are asking more sophisticated questions and, as a result, finding important differences in comprehension patterns. And third, study participants are increasing assuming they have scored higher when reading onscreen – even though they haven't. (More on that a bit later.)

Now that we have many years-worth of data, researchers can map findings across multiple studies (producing meta-analyses or systematic reviews).[8] Here are three areas in which students usually do better with print:

- On longer texts (typically over about 500 words)
- When answers require abstraction or inference[9]

- When answers require more detail (not just the main points)[10]

That is, when it comes to more cognitively-demanding learning, print shows an advantage over digital text.

Interestingly, researchers also discovered that the more recent the study was, the more likely that students performed better with print. Intuitively, we might assume the opposite: that as students used increasing amounts of digital materials in their lives, they would become more skilled when reading onscreen. However, as we'll see later on, all this digital experience – especially with casual reading associated with social media – seems to result in shallower onscreen reading.

Using Multiple Texts

One of the biggest curricular shifts in recent years, especially in middle and high school, has been assigning students to search for, evaluate, and synthesize multiple online documents. Assessment of these skills is increasingly appearing in standardized testing, including the international PISA test for 15-year-olds.

Researchers are now examining how adept – and astute – students are in using multiple online materials. I've summarized these findings elsewhere.[11] But some of the results bear on print reading in important ways.

First, it's clear that print comprehension skills are strong predictors of higher scores when using multiple online documents.[12] In essence, print skills are transferable. That finding makes sense, given the overlap in skills needed for reading single print documents and for working with multiple documents online. These abilities include drawing upon prior knowledge of the topic, using inferential reasoning strategies, and knowing when to reread and how to evaluate what you've read.[13]

Second, there's evidence that print has some advantages over digital when using multiple documents. But as with reading single print versus digital texts, these advantages tend to emerge when you ask detailed or subtle questions rather than more superficial ones. Here's some of the evidence:

- Students were given two sets of materials to read (one set in print, the other as hyperlinked texts). For each set, there was a main text plus auxiliary documents. In a comprehension test, students did equally well with print and

digital when it came to questions about the main text. However, they did better with print for questions about the auxiliary texts, presumably because students read them more carefully than the digital ones.[14]

- Another experiment compared multiple print versus digital documents for a comprehension test that asked students to draw inferences. When students were asked to read the materials as if they were preparing for an exam, they wrote longer responses and showed more integrated understanding of the issues when they used print.[15]

Given the growing use of multiple documents in today's secondary curricula, it's important to recognize that medium matters here as well. In most school settings, those multiple documents are accessed digitally. However, research suggests that when it comes to more in-depth student analysis, print tends to be more effective.

Standardized Testing Issues

All the research we've been looking at was based on one-off testing: ask students to read one or more documents and then assess their comprehension. What about more long-term measures? There are two ways of asking this question. The first: what happens when students take a traditional high-stakes test on paper versus on a digital screen. The second: does the amount of digital screen usage in classroom settings have an impact on reading scores in standardized tests.

Testing Format: Paper or Screen

Long before the pandemic, standardized testing was moving online. The Educational Testing Service was one of the first to experiment with digital formats for its college entrance and professional school assessments, though digital testing soon moved to the K-12 space. These days, the international PISA exam for 15-year-olds, along with the international PIRLS for 4th graders and the US "Nation's Report Card" for 4th, 8th, and 12th graders, are essentially all digital. Among the arguments for shifting to digital are cost, convenience, and expanded possibilities that computers offer, including for using video and for accessing multiple online documents.

Does the testing format matter? If it does, we could be misjudging some of our students' reading abilities if they perform better in a different medium from the one used for assessment. Test designers obviously wrestled with this question as they transitioned to online tools, but challenges remain going forward.

Given what we've already learned about comprehension disparities between reading in print versus onscreen, it's no surprise to find a number of researchers worried about the shift.[16] Here are some of their reasons for concern:

- Studies in Norway (with 5th graders and 10th graders), New Zealand (4th through 10th graders), and the US (3rd through 8th graders) showed better standardized test results for the paper than for the digital version.[17]
- In the US study, the negative effects of digital administration were strongest for more vulnerable students: those with low reading achievement scores, English language learners, and special education students.
- Among Norwegian 5th graders, scores on the paper version were significantly higher on the more cognitively demanding "constructed responses". By contrast, they were slightly better in the digital version on the less demanding multiple-choice questions.[18]
- In a different test for Norwegian 5th graders, the girls in the study who had the highest overall level of reading achievement suffered the most in terms of low scores when assessed digitally.[19]

NAEP: National Assessment of Educational Progress ("The Nation's Report Card")

A second approach to thinking about medium and testing is to ask whether classroom use of digital devices corresponds meaningfully to children's reading skills. The National Assessment of Educational Progress offers some tantalizing data. (Reading data are assessed bi-annually.) The relevant results for us here are the number of hours that digital devices were used in language arts classrooms for 4th and 8th graders:

- For both 2017 and 2019, higher reading scores on the NAEP correlated with lower use of digital devices.

- Here are illustrative results for the percent of 4th graders in 2019 who scored as "proficient" or "advanced" readers, by daily amount of time using a digital device for language arts schoolwork:[20]

<30 mins	c. 30 mins	c. 1 hour	c. 2 hours	c. 3 hours	≥ 4 hours
40%	36%	34%	31%	24%	13%

That is, the more time spent with digital devices, the fewer students who were "proficient" or "advanced" readers. Obviously, correlation doesn't establish causation. It's critical to know how the digital devices were being used. (For instance, were students doing online research or repetitive drill exercises?[21]) But the numbers themselves urge us to consider whether heavy use of digital devices in the language arts curriculum advances students' reading skills.

What Do Students Think?

Most research on the impact of print versus digital medium on learning involves some version of testing. However, surely it also makes sense to ask students about their own perceptions. Yes, self-reporting has its challenges as a research methodology, but it also can provide an invaluable window into students' thinking – especially when one study after another shows similar results.

Perception Studies

My own research, and that of colleagues, has surveyed secondary school and university students, asking a host of questions about their use of print versus digital reading platforms.[22] In each case, we've inquired about reading in general, not in the limited context of school-based one-off tests.

Results have been consistent across studies. Most relevant for us, the clear preponderance of students say that with print it is easier to

- Concentrate
- Learn
- Remember

than with digital text. Here are examples of what students wrote about the benefits of print:

"I don't get distracted."

"Reading in hardcopy makes me focus more on what I'm reading."

"Feel like the content sticks in the head more easily."

"I feel like I understand it more."

These answers are important because ultimately, we care about learning for the long haul. They are also interesting because they're at odds with results from studies asking about perceived performance on a single test – a case we'll get to in a moment.

Students also had consistent observations about text length. The vast majority said that with longer materials they prefer reading in print. (For shorter texts, their answers were a mixed bag.) However, when asked what they like or dislike about reading in print or digitally, several complained that print was "longer" and took longer to read (even when print and digital versions were exactly the same).

"[Digital] looks shorter to read on."

"[What I like least about reading print is that] it takes me longer because I read more carefully."

That second comment should give us particular pause. The student is revealing an important point for us to keep in mind as we weigh choice of reading platforms: beyond the advantages or drawbacks of particular physical "containers", readers have preconceptions about how much of their mental attention a medium deserves.

Complaints about length lead us to an unexpected comment from a number of students: print is boring, while digital texts are more entertaining. In research my colleagues and I did with secondary school students, we received comments like

"Print can tire you out really fast and get boring no matter how interesting the book is."

College students I've surveyed had similar complaints about print:

"Just boring material and hard to read."

"It takes time to sit down and focus on the material."

And in a study conducted for the UK National Literacy Trust with children age 8 to 16, one student grumbled that

> *When you read on paper, it's a bit boring, unless it's something you're really into …. On a tablet, it feels more interesting, it reminds me of when I'm texting someone.*[23]

Harkening back to the length issue, another UK student said

> *"On paper, there's just too many words on the page and it's too long, you get confused."*

But digital technology can also provide motivation. Multiple studies with middle and high school students indicate that especially for boys and reluctant readers, digital devices not only are preferred over print but can increase engagement and even enjoyment of reading on paper.[24] Motivation is critical both for reading in general and particularly for reading print. A continuing challenge facing educators is to make print reading interesting, given the competition of enhancements – and distractions – when students access material online. These are some comments from secondary school students about what they like most regarding reading on digital screens:

> *"It can be a bit more entertaining."*
>
> *"It keeps me awake."*

"Calibration" Issues

There's another way of looking at students' perceptions: compare how test-takers think they will do (or just did) on a reading comprehension exam against actual results. Psychologists call this comparison "calibration". Results from calibration studies when reading print versus digital text are telling. Multiple studies now show that students are more likely to overestimate their performance when reading onscreen compared with using print. Evidence comes from across the student age spectrum.[25]

Researchers suggest the reason for the mismatch between prediction and success is that students believe it will be easier to comprehend the digital text and therefore don't try as hard as with print.[26] Remember the student who complained that when reading in print, "*It takes me longer because I read more carefully."* We'll be looking next at this issue of effort.

More Aspects of Reading

Besides experimental studies, formal testing situations, and students' perceptions, considering other aspects of reading can further our understanding of how medium impacts learning. We'll look here at effort, speed, annotation, and pleasure reading.

Effort

AIME. It's a technical term in educational psychology, meaning "amount of invested mental effort". The notion dates back to the 1980s with an experiment that asked 6th graders to judge the amount of effort needed to understand a film watched on television versus when reading a comparable text. The children felt they would do better with the TV film, which they also thought would take less effort. Indeed, they seemed to expend less mental energy with the TV version, since they performed better on a comprehension test when reading print.[27] In short, the children had difficulty with calibration.

These days, the culprit isn't television but the internet, especially how we use it for leisure purposes, including social media. Students (and to be fair, many of the rest of us) have taken to believing it doesn't take much effort when reading digitally. While that assumption may be true for checking news headlines or viewing Facebook updates, it's a hazardous strategy when using a digital device to read something meriting more concentration.

Researchers today talk about a "shallowing hypothesis", meaning we tend to approach all our digital reading with the kind of low-effort mindset we fall into for things like social media.[28] The shallowing hypothesis may explain why so many students show better comprehension scores when reading print test material,[29] as well as why they think it takes longer – and more effort – to read in print. We shouldn't be surprised at research showing that higher use of online social media correlates with lower reading scores.[30]

Speed

Another issue on the minds of researchers and educators is whether students read digital texts more quickly than they read print. The answer isn't straightforward, in part because when many of us read online, we're also multitasking with other activities. Accordingly, the time it takes to finish a digital text can be longer than for print. However, let's take away the multitasking scenario and put students in a formal testing situation where they may

choose how much time to spend. There's some evidence that students read the digital version more quickly – and then do worse on a subsequent comprehension test.[31] Not all studies show these results, but when they do, we're reminded about the assumptions students make about how much effort they need to exert on a digital reading task.

Annotation

When we read in print, many of us tend to have a writing implement in hand. The practice of annotating text goes back centuries. These days, annotations might include underlining, highlighting, use of arrows or other symbols, or what's known as marginalia – writing your own words in the margin.

Marginalia supports active engagement with what you're reading. It also slows down the reading process, since you need to stop, think, and write rather than continually plowing ahead, sometimes with eyes glazed and mind elsewhere. While underlining and highlighting are forms of annotation, research has long shown they are not particularly effective tools for sustained learning.[32]

What happens when we read digitally? Today, there are multiple tools for annotating digital text, including underlining, highlighting, and marginal notes. But do students annotate digital reading as much as with printed text, especially by adding notes of their own? Not usually.

The challenge of digital annotation has many faces. Here are the main ones:

- Software tools for digital annotation aren't all as easy to use as an old-fashioned pen or pencil.
- Many students aren't trained to do digital annotation, so often it doesn't happen. However, they can be taught.[33]
- Physical manipulation of a handwriting tool when making notes is a better aid to memory than a keyboard or touchpad.[34]
- Students' attitudes towards digital reading can play a significant role regarding annotation. If you don't view digital text as meriting careful reading, there's little motivation to slow down and annotate meaningfully.

Reading for Pleasure

This Report focuses on the reading students do in educational settings. We'd like to hope students are supplementing their school assignments with leisure reading. But how much are they – and does the kind of leisure reading they do matter?

Let's start with some statistics. The 2019 Common Sense Census: Media Use by Tweens and Tweens[35] found that both groups (8 to 12-year-olds and 13 to 18-year-olds) were averaging 29 minutes of pleasure reading a day. The major difference between the age groups was how much (average) daily leisure reading involved print:

	8 to 12-year-olds	13 to 18-year-olds
Print books	21 minutes	12 minutes
Ebooks	5 minutes	8 minutes
Online (e.g., news stories, blogs, articles)	1 minute	7 minutes
Magazines or newspapers	2 minutes	2 minutes

Whichever way you slice it, 29 minutes of leisure reading is hardly an impressive number – especially in comparison with the average daily time spent using screen media more generally:

8 to 12-year-olds	13 to 18-year-olds
4 hours 44 minutes	7 hours 22 minutes

Before we lean too heavily on young people for doing so little leisure reading, we need to recognize that most adults aren't reading much for pleasure either. The American Time Use Survey (conducted each year by the US Department of Labor) reported that in 2019, adults (here, meaning age 15 and older) were only averaging about 16 minutes per day of pleasure reading.[36] Another study, this time by the Pew Research Center, found that 27% of adults in the US hadn't read a book (in whole or in part, whether in print, digitally, or as an audiobook) in the past year.[37]

Intuitively, we know that reading for pleasure enhances reading skills, including the ones we measure in school. We also probably suspect that the kind of reading matters. Entire books rather than short pieces. And lots of fiction. Research drives these points home:

- 15-year-old students who read fiction had higher scores on the international PISA reading test than those who didn't. Reading magazines, newspapers, comics, or nonfiction didn't give a similar boost.[38]
- A study with 11 to 15-year-olds concluded that reading fiction books made a unique contribution to inference-making abilities.[39]
- Middle schoolers who read fiction for pleasure had stronger reading comprehension and vocabulary development.[40]
- 7 to 16-year-olds who did frequent leisure reading, especially of book-length works, showed better reading comprehension. No increase in reading scores for children who chose magazines, newspapers, or comics as their leisure reading.[41]

None of these studies reported whether the longer reading was done in print or on digital devices, though I suspect most of it was in print.

For children who are avid readers and love using a tablet for stories and novels, the medium may not always be important. In fact, some of the experimental research indicates that comprehension advantages for print are stronger for informational materials (think of textbooks) than for narrative (think of novels).[42] That finding makes sense. Texts that are information-heavy demand more attention and concentration than most of the narrative reading we do. And while language arts and then literature classes assign narrative works, most school reading skews towards information.

What About Other Media?

Written text isn't the only type of learning material. Film strips and movies were long part of the educational mix. What's different today is the growing place of online audio and especially video in school settings.

Audio

We can debate whether it's appropriate to talk about listening to podcasts or audiobooks as forms of reading.[43] Whatever the label, a lot of children are "reading with their ears" rather than their eyes. We won't here weigh the pros and cons of this trend. (If you're interested,

see Chapters 7 and 8 of *How We Read Now* for an overview.) However, there are a few lessons worth sharing, since this Report is about reading and learning.

The first point is about motivation. For some children (especially reluctant readers, and especially boys), audiobooks can be a valuable motivator to get them reading.[44] That enthusiasm can transfer to print.

But what about learning from audio? There isn't a lot of research comparing audio versus written text. (Moreover, reports don't always specify what text medium, though generally it seems to have been print.) Yet the experiments we do have with students from middle school through college age largely find better comprehension with written material than with audio.[45]

Reasons for the text benefit aren't hard to figure out. Among the advantages of text over audio are:

- Ability to read at your own pace, including pausing and rereading
- Ease of annotation (with audio, there aren't yet simple annotation tools)
- Presence of "landmarks" that divide the material into chunks (such as punctuation, paragraphing, and section headings), helping students both parse and integrate what they're encountering

Several other factors may contribute to the disparity. One is mental effort. As one group of researchers observed, the reason that audio comprehension lagged behind reading comprehension in their experiment was that with audio, students failed to invest the mental effort.[46] As you'll remember, reduced mental effort likely accounts for some of the difference between digital screens and print for reading comprehension.

A related issue is mind-wandering. To determine whether students are attending to the task at hand, researchers have stopped them (say, every 10 seconds) and asked what they were thinking about. One study compared the amount of mind-wandering when listening to audio versus reading the same text silently. No surprise: more mind-wandering with the audio. However, the least mind-wandering happened when students read the text aloud themselves.[47]

Video

Educational possibilities for video exploded with the internet. During the pandemic, with lessons and learning materials moving online, the ready availability of video increased its use even more. Needless to say, video can be a powerful medium for its content, aesthetics, and emotional impact. But how does it measure up against text when it comes to learning?

The question is complex, since you need to compare apples to apples. A video of how to toss pizza dough is more helpful than a step-by-step written description. The same goes for explaining how cells in the human body divide. But what about content that is largely comparable, say of a movie or a video-recorded lecture versus a transcript?

As with audio versus text, there's not a lot of research. However, what we do have again suggests that more learning takes place with the transcript.[48] Besides measuring memory for content, we can also ask about deeper levels of understanding, say in the kinds of essays students write after viewing a video or reading a transcript. A study with 4th to 6th graders offers useful insights. Researchers asked students to synthesize information they encountered in multiple sources either by viewing videos or by accessing digital texts. One assessment measure involved remembering what the source of their information was. Performance was the same for video and digital text. But the second measure was to write an essay. Here's where differences between media surfaced:

- Students were more likely to defend the views presented in the videos than in the text.
- Students who read the texts made almost twice as many inferences as those who saw the videos.[49]

Think back to what we saw with experimental studies comparing print versus digital text. For simple questions, sometimes performance was equivalent. However, when researchers asked more probing questions, print results were typically stronger. In this study comparing video with text, the authors hypothesize that students may have been "reading" the videos more superficially than the written text because their familiarity with video is largely for leisure, not formal learning. We might call this attitude "video shallowing".

What Have We Learned?

We've looked at a wide range of research about the role of reading medium when it comes to learning. As we sum up our findings, please keep four caveats in mind:

- We are talking about reading single linear texts of at least a couple hundred words, not other kinds of reading.
- Where relevant, we've mentioned pleasure reading and social media, but our focus is on reading in educational settings.
- Digital technologies can be highly effective learning tools. Our challenge as educators is recognizing when they are productive and when print is the better choice.
- As with much social science research, our conclusions reflect findings for most (or at least many) students, not for absolutely everyone.

Major Findings

Reading in print generally proves more successful than reading the same material digitally when learning from written text. This finding reflects a combination of two factors:

- The properties of paper and the ways we interact with it
- Readers' mindsets about the mental demands of reading print versus digital material

The relative importance of each factor probably differs across individuals.

Evidence of Cognitive Advantages

Both experimental studies and surveys of students' perceptions lend support to cognitive benefits of reading in print, particularly for educational purposes:

- EXPERIMENTAL RESULTS

  Reading scores with print are generally higher when students are asked to
  - read longer texts
  - deal with abstractions
  - make inferences
  - remember details
  - remember when and where in a story an event occurs

The print advantage is often more common with informational texts than for narrative (typically fiction) reading.

- PERCEPTUAL STUDIES

  Most students surveyed report that reading in print is better for
  - concentration
  - learning
  - remembering

That is, students' own perceptions about the educational value of print are consistent with the stronger performances they demonstrate with print in formal experiments.

"My concentration increases while reading from a hard copy."

"Everything sinks in more and you can picture it more vividly."

Don't underestimate the importance of what students say about the reading medium on which they believe they learn best. While one-off experiments in controlled testing situations can measure comprehension on relatively short written passages, they can't tell us how students approach reading more substantial texts when they are at home or in a library. The consistency of students' observations – across ages and countries – underscores the vital role that print continues to play in the learning process.

Perceptual Judgements about Properties of Paper

Students are sensitive to the properties of paper when they read. Their observations include comments about the importance of touch, smell, and sight. The tangible qualities of print can also have emotional and motivational consequences:

"It's nice to see book piling up as you finish reading."

"I enjoy being able to see how far I have gotten and somehow it motivates me to keep going."

The physicality of print also leads to observations about authenticity and ownership:

- AUTHENTICITY

  A number of students describe reading in print as "real reading":

  "Feel that I am actually reading."

"It feels more authentic."

Recall experimental findings that students' essays were richer when using authentic print reading materials than with printouts.

- OWNERSHIP

  Some students comment on their physical relationship to print:

  "Printed media give me a feeling of ownership … you don't put digital media on your bookshelf."

Mindset Issues

Both experimental studies and surveys of students' perceptions highlight the importance of mindset when we compare reading in print versus digitally:

- EXPERIMENTAL RESULTS
  - Many students invest less mental effort when reading digitally, resulting in lower comprehension.
  - The shallowing hypothesis (that we use a social media-style mindset when reading longer digital text) helps explain lower expenditure of effort and lower comprehension with digital reading.

- PERCEPTUAL STUDIES

  Some students report that
  - digital text looks shorter than print
  - print takes longer to read and requires more concentration
  - digital text is more entertaining, while print can be boring

Testing Conundrums

The first testing issue involves calibration between students' perceptions and actual results in one-off testing:

- Today's students commonly believe they scored (or will score) higher on a one-off reading comprehension test with digital text, though they generally do better with print.

- Student assumptions about success in one-off testing are at odds with their perceptions about broader learning (that is, reporting that print is the better medium for concentration, learning, and remembering).[50]

The second testing issue concerns the growing move away from print to digital for high-stakes standardized testing:

- Some students score higher on print versions of standardized tests than on digital versions, especially on questions involving "constructed" rather than multiple choice answers.
- Students about whom we should be particular concerned include
  - those with low reading achievement scores
  - English language learners
  - special education students
- Digital testing may underrepresent the reading skills of children (especially girls) who are otherwise documented to have high reading comprehension.

The third testing area involves use of digital devices in the classroom. The issue here isn't testing medium but possible impact of classroom practices on test scores. Results from the NAEP suggest that

- Protracted use of digital devices in classrooms may decrease, rather than foster, reading achievement.

Where Do We Go from Here?

How can we apply what we've learned to real-world education? Every school setting is different, as are such realities as budgets, administrative hierarchies, and parental pressures. The pandemic further complicated everyone's educational practices and decision-making. However, here are some general steps to consider.

Step 1. Keep Learning Goals Front and Center

The research has taught us the continuing importance of physical books in children's education. Digital has its place as well, but for sustained concentration, thinking, and mindful analysis, print remains the better medium.

Step 2. Listen to Learners

Anyone who teaches understands we can learn an incredible amount from our students. My own experience working in universities taught me that while decision-makers assumed students preferred to learn digitally (given how much time they spend online, including on social media), surveys of students themselves often showed otherwise.

My second suggestion is therefore to explore students' own perceptions about reading medium, especially when reading for school purposes. You might administer a short survey and talk together about the results. (For ideas, see the **Questions for Students about Print and Digital Reading** at the end of this Report.)

Step 3. Share What We Know

We now know a good deal about the value of print when reading in schooling contexts, though people in the education world are often unaware of the supporting research. It's important to share findings with everyone having a stake in the teaching and learning process, including teachers, librarians, administrators, students, and parents. Here are a few potential venues:

- townhall meetings for the school community
- in-service training sessions for teachers
- continuing education opportunities for teachers
- curricular unit for students
- discussions with parents
- meetings with decision-makers who select learning materials

Step 4. Make Informed Choices of Learning and Testing Materials

Decision-making authority for learning materials can lie at a variety of levels: the classroom, grade, school, district, or state. When it comes to formats for standardized tests, choices might be at the state, national, or international level. Whether or not control is in your hands, here are some points to keep in mind:

- *FOR LEARNING MATERIALS*

- When there are format options, consider the pros and cons of each. Balancing cost, convenience, and learning can be challenging, but don't leave learning out of the equation.
- Students recognize that format choices can involve making tradeoffs. For instance, as one college student said,
  "While I prefer reading things in Hard copy, I can't bring myself to print out online material simply for the environmental considerations."

- *FOR TESTING MATERIALS*
  - Remember that not all students do equally well in print-based and digital testing. This lesson is especially important for children with known reading challenges and for those who may be more comfortable reading in one medium.

College faculty are concerned that the high cost of print textbooks often stops students from procuring copies.[51] K-12 teachers and administrators face similar challenges, needing to balance accessibility, affordability, and suitability for encouraging long-term learning.

Step 5. Develop and Implement Curricular Changes

This last step is perhaps the hardest, since there's very little translational work applying the research to classroom curricula. Hopefully, over the next few years, there will be useful curricular materials – including ideas coming from readers such as you. In the meanwhile, here are a few classroom (and related) suggestions to consider:

- *EDUCATING STUDENTS*

  Issues to talk about:
  - the role of mindset in how we tend to read digitally
  - calibration between expectations and actual performance
  - translating print reading skills to digital reading

- *EDUCATING TEACHERS*

  Issues to work on:

- balancing print and digital materials to support learning in both media[52]
- translating print reading skills to reading digitally
- where appropriate, using eBooks as motivators to read
- making time for reading print in class

- *EDUCATING PARENTS*

  Conversations to have:

  - Importance of modeling focused print reading at home

There are many ways in which both educators and parents can advocate for ensuring that print remains an important part of education. I hope this Report will be helpful in your endeavors going forward.

Questions for Students about Print and Digital Reading

Here are potential questions you might ask students in a survey of their reading habits and preferences. Most questions are drawn from a larger survey that my colleagues Kim Tyo-Dickerson, Anne Mangen, Frank Hakemulder, and I created for a study of secondary school students in Europe. By using an online survey tool, it's easy to collect and share your findings.

If you do survey students, my colleagues and I would love to see your results (nbaron@american.edu).

Concentration and Understanding

You may be able to <u>concentrate</u> more on your reading (that is, not get distracted or multitask) when using some media more than others. Please rate your ability to concentrate when reading on each of these media:

	Easier to concentrate			*Harder to concentrate*
	1	*2*	*3*	*4*	*5*
print					
computer					
tablet or eReader					
smartphone					

You may find you <u>understand</u> more (make sense of what you are reading) when using some media more than others. Please rate your ability to understand when reading on each of these media:

	Easier to understand			*Harder to understand*
	1	*2*	*3*	*4*	*5*
print					
computer					
tablet or eReader					
smartphone					

Multitasking

When you are reading <u>in print</u>, how often are you multitasking? (Don't include listening to music as part of multitasking.)

Never				*Very often*
1	*2*	*3*	*4*	*5*

When you are reading <u>on a digital screen</u>, how often are you multitasking? (Don't include listening to music as part of multitasking.)

Never				*Very often*
1	*2*	*3*	*4*	*5*

Likes and Dislikes

What is the <u>one thing</u> you like <u>most</u> about reading in print?

What is the <u>one thing</u> you like <u>least</u> about reading in print?

What is the <u>one thing</u> you like <u>most</u> about reading on a digital screen?

What is the <u>one thing</u> you like <u>least</u> about reading on a digital screen?

Reading Time

Think about how long it takes for you to read a school assignment. Does it take more time when the text is in print or on a digital screen? Choose one of these answers:

___ more time in print
___ more time on a digital screen

Boredom

Please share your personal feelings about reading in print or on a digital screen. Think about your overall reading, not just one book or assignment. For each question, choose the number on the 5-point scale that matches your answer.

Reading in print is boring.

strongly agree				*strongly disagree*
1	*2*	*3*	*4*	*5*

Reading on a digital screen is boring.

strongly agree				*strongly disagree*
1	*2*	*3*	*4*	*5*

Effects of Distance Learning on Reading Preferences

Because of COVID-19, most school lessons went online, and a lot of reading assignments also moved from print to digital formats. Please share whether these changes affected how you feel about reading in print or on a digital screen, and about reading in general. For each question, choose the number on the 5-point scale that matches your answer.

I now <u>like</u> digital reading more than I used to.

strongly agree				*strongly disagree*
1	*2*	*3*	*4*	*5*

I now <u>dislike</u> digital reading more than I used to.

strongly agree				*strongly disagree*

1 2 3 4 5

I missed reading more print.

strongly agree strongly disagree

1 2 3 4 5

I now want to read more in general.

strongly agree strongly disagree

1 2 3 4 5

I got really tired of doing so much schoolwork on the computer.

strongly agree strongly disagree

1 2 3 4 5

Resources

Planet Word

In 2020, a new inspiring and engaging museum opened in Washington, DC, called Planet Word. The museum, founded by Ann Friedman, invites us to explore the wonders of language, including reading. Here's the museum website: https://planetwordmuseum.org

Children and Screens

This organization is devoted to research and public understanding of the effects of digital technologies on children's lives, including when they read. Children and Screens hosts practical webinars and offers multiple tips for parents. Their website is https://www.childrenandscreens.com. Have a look at their tips for parents on reading in a digital world at https://www.childrenandscreens.com/media/press-releases/oh-the-places-theyll-go/.

e-READ

The E-READ project, funded by the European Union, examined reading in the age of digitization. The four-year study involved almost 200 researchers. You can learn more about the project and its findings at https://ereadcost.eu. An important summary statement about reading in print versus digitally appears in the Stavanger Declaration, which you can read at https://ereadcost.eu/wp-content/uploads/2019/01/StavangerDeclaration.pdf

Notes

1. For a picture of what university students see as the pros and cons of reading in print versus on digital screens, see Baron, Calixte, and Havewala 2017; Mizrachi et al. 2018; and Mizrachi and Salaz 2020.

2. A powerful example is Perusall (https://perusall.com), a program created at Harvard but now used, for free, by a million students around the world. Students read and annotate texts digitally on a shared platform, stimulating online conversation with each other and enabling the teacher to review their questions before the next class meeting.

3. Delgado et al. 2018; Higgins, Russell, and Hoffmann 2005; Pommerich 2004.

4. Preschoolers: Parish-Morris et al. 2013; young adults: Mangen, Olivier, and Velay 2019.

5. Salmerón, Gil, and Bråten 2018.

6. Baron, Calixte, and Havewala 2017.

7. For more on these early studies, see Baron, Calixte, and Havewala 2017.

8. Clinton 2019; Delgado et al. 2018; Singer and Alexander 2017a.

9. Kaufman and Flanagan 2016.

10. Singer and Alexander 2017b.

11. Baron 2021, Chapter 5.

12. 7th grade: Coiro 2011; 7th – 10th grade: Naumann and Salmerón 2016; Salmerón, García, and Vidal-Abarca 2018; 15-year-olds: OECD 2015, p. 94.

13. Coiro and Dobler 2007.

14. Macedo-Rouet et al. 2003.

15. Latini et al. 2019.

16. Støle et al. 2018.

17. Norway: Støle, Mangen, and Schwippert 2020; Mangen, Walgermo, and Brønnick 2013; New Zealand: Eyre 2017; US: Backes and Cowan 2019.

18. Schulz-Heidorf and Støle 2018.

19. Støle, Mangen, and Schwippert 2020.

20. Sparks 2019.

21. Salmeron et al. 2020.

22. Baron, Calixte, and Havewala 2017; Mizrachi et al. 2018; Tyo-Dickerson et al. 2019.

23. Picton and Clark 2015.

24. Fletcher and Nicholas 2016; Picton and Clark 2015; Tveit and Mangen 2014.

25. 5th and 6th graders: Golan, Barzillai, and Katzir 2018; Halamish and Elbaz 2020; college: Ackerman and Goldsmith 2011; Singer and Alexander 2017b.

26. For example, Clinton 2019; Sidi et al. 2017.

27. Salomon 1984.

28. Annisette and Lafreniere 2017.

29. Delgado et al. 2018.

30. Duncan et al. 2016; Pfost, Dörfler, and Artelt 2013.

31. Ackerman and Goldstein 2011.

32. Dunlosky 2013.

33. Turner and Zucker 2020.

34. Mueller and Oppenheimer 2014.

35. Rideout and Robb 2019.

36. Bureau of Labor Statistics n.d.

37. Perrin 2019.

38. Jerrim and Moss 2019.

39. Duncan et al. 2016.

40. Pfost, Dörfler, and Artelt 2013.

41. Torppa et al. 2019.

42. Clinton 2019; Delgado et al. 2018.

43. Have and Stougaard 2016; Rubery 2016.

44. McAllister et al. 2014.

45. Daniel and Woody 2010; Diakidoy et al. 2005; Furnham 2001; Rubin, Hafer, and Arata 2000.

46. Rubin, Hafer, and Arata 2000.

47. Varao Sousa et al. 2013.

48. Furnham 2001.

49. Salmerón et al. 2020.

50. Studies on calibration and on perceptions about learning more generally haven't involved the same students. However, I predict future research will establish that at least many of the same individuals hold both beliefs.

51. Seaman and Seaman 2020.

52. For excellent guidance on productive classroom use of both print and digital learning resources, see Turner and Hicks 2015.

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