The Learning Science of Digital Reading

Digital reading presents unique opportunities for dynamic learning

A new era of learners is being educated with digital reading tools and technology rather than being introduced to a digital format later in life (Ross, Pechenkina, Aeschliman, & Chase, 2017). Digital content presents unique advantages over print material because of opportunities to introduce interactive content and gauge assessment within the learning experience (Chen et al., 2019). Whereas previous research showed comprehension deficits when comparing print to digital reading (Kong, Seo, & Zhai, 2018; Sidi, Shpigelman, Zalmanov, & Ackerman, 2017), new research shows digital reading comprehension is comparable to print (Alisaari et al., 2018; Latini, Bråten, & Salmerón, 2020). Although students engage with digital content more than print in their courses (Sage et al., 2019), readers rate lower confidence in reading performance when reading digitally (Jeong & Gweon, 2021). Individual differences in a learner's digital reading experience and preferences can influence reading comprehension (Coiro, 2021). New research shows training students to read digital content effectively and engage with the material results in better comprehension performance and increased confidence in reading abilities (Trakhman, Alexander, & Silverman, 2018). Likewise, digital content designed with a simple, unified layout and navigational aids can reduce extraneous cognitive load and improve the reader experience (Hou et al., 2017). The following design suggestions are recommended to improve the digital reading experience.

Design for Learning in Digital Reading

Teach students how to read effectively
- Train students how to use the digital reading tools
- Encourage students to read with intention
- Utilize navigational aids to map information

Engage students with active learning opportunities
- Intersperse text with interactive exercises
- Reduce cognitive load by keeping the format simple and the text short
- Consider the reading device type and ensure the reading capabilities are useable

Motivate students to improve reading habits
- Model other classmates' reading behaviors to encourage better habits
- Create customization in the reading format to account for individual differences
- Detect mindless reading by introducing reading "check-in's" that assess comprehension

Teach students how to read effectively

Train students how to use the digital reading tools

Students tend to have overconfidence in their digital reading behaviors, likely because print reading skills are comparable to digital reading (Johnston & Ferguson, 2020; Nichols, 2020). However, due to the versatility of digital design and features, digital reading demands additional cognitive load and requires different skills to comprehend the material (Hou, Rashid, & Lee, 2017). Therefore, including a pre-training section to signal the organization of the information can improve reading skills and increase reading efficiency (Clinton-Lisell, Kelly, & Clark, 2020; Latini, Bråten, & Salmerón, 2020).

Design Recommendations
- Begin the reading session with a guide pointing out the formatting structure of the text
- Implement easy-to-find learning objectives to focus learners towards the relevant content

Encourage students to read with intention

Research shows students read digital content faster than print (Köpper, Mayr, & Buchner, 2016), and retain less information, especially when the reading is timed (Delgado, Vargas, Ackerman, & Salmerón, 2018; Sidi et al., 2017). However, students who actively take notes and highlight digital material show better comprehension performance and sharing notes can train other students how to read effectively (Kim et al., 2020; Long, Juarez, & Hinze, 2020). Students with higher comprehension scores also highlight less digital reading content, but the highlights were more targeted towards the relevant information compared to print reading highlights (Goodwin et al., 2020). Digital reading can be designed to promote slower, more intentional reading that results in deeper thinking and better comprehension (Lim, Whitehead, & Choi, 2021).

Design Recommendations
- Implement note-taking options within the text (pre-train on note-taking functionality)
- Allow peers to share annotations with each other
- Make suggestions to improve notetaking based on shared annotations

Utilize navigational aids to map information

Readers show a deficit in their ability to construct a cognitive map of digital text compared to print reading because of the lack of physical cues within the digital device (Hou et al., 2017; Mangen, Olivier, & Velay, 2019). Students prefer an interactive interface that is easy to navigate with the facility to keyword search (Casselden, & Pears, 2020). Text formatting that indicates importance and organization of the text (e.g. bold, highlighted, underlined) also promotes reading comprehension because it helps students build a cognitive map of the text (Shi et al., 2020).

Design Recommendations
- Implement hierarchical graphical overviews
- Implement tools for navigating to specific places within text
- Design a systematic formatting to understand the layout of information

Engage students with active learning opportunities

Intersperse text with interactive exercises

Readers show deficits in comprehension when reading digital information when the layout of the material is comparable to print reading (Clinton, 2019). However, research measuring shorter reads (~500 words) show comprehension does not differ between print and digital reading (Nichols, 2020b). Breaking up text with interactive features such as questions with feedback, digital glossaries, and collaborative tools can aid readers and prevent cognitive depletion (Ballenghein, Kaakinen, Tissier, & Baccino, 2020). Research shows that interactive features benefited reading performance when engaging with digital reading material (Clinton-Lisell, 2021), as long as the interactive features are integrated and do not distract from the material (Furenes, Kucirkova, & Bus, 2021).

Design Recommendations
- Segment long text with visual content (i.e. videos, graphs, images)
- Implement tools to collaborate with peers or look up definitions during reading (pre-train on functionality)

Reduce cognitive load by keeping the format simple and the text short

Multimedia has opportunities to present interactive and engaging information; however, extraneous information or poorly designed features can decrease the quality of the learning experience. Research shows that students show better comprehension when material is chunked into shorter segments and scaffolded (Nichols, 2020). Likewise, features such as scrolling or irrelevant hyperlinks can increase cognitive load and decrease comprehension (Sage et al., 2020). When designing digital content, implement simple, deliberate designs rather than replicating a print experience.

Design Recommendations
- Accompany hyperlinks with onclick events/actions
- Reduce or eliminate scrolling requirements
- Manipulate visual properties of text to guide attention and boost cognitive engagement

Consider the reading device type and ensure the reading capabilities are useable

Students commonly report reading course materials on a laptop compared to print, e-readers/tablets, or a phone (Sage, Piazzini, Downey IV, & Masilela, 2020). Because laptops are commonly used for online learning, students show equivalent comprehension when reading digital content on a laptop and printed reads (Köpper, Mayr, & Buchner, 2016). However, due to lack of familiarity and complicated digital design, students show worse performance and decreased enjoyment when reading non-fictional content from an e-reader (Sage et al., 2020), although this difference is not significant when reading fictional narratives (Schwabe, Brandl, Boomgaarden, & Stocker, 2021). When designing for digital reading content, the functionality of the device type and features should be considered.

Design Recommendations
- Advise users to avoid eye fatigue by decreasing screen luminance and/or use anti-glare screen treatment through periodic messages
- Ensure features are operable for both laptop and e-reading formats
- Implement easy-to-use training to use the features

Motivate students to improve reading habits

Model other classmates' reading behaviors to encourage better habits

Students lack motivation to read because they do not have the skills needed for effective comprehension or they find the material disengaging (Coiro, 2021). However, social components of learning can improve motivation to engage with digital reading materials. Icicle plots of students' own textbook reading and performance and social comparison with classmates motivated students to read (Barria-Pineda et al., 2019). Therefore, digital reading tools that encourage socialization within the context of learning could motivate students to engage in better habits.

Design Recommendations
- Implement a utility for socialization (ask questions, share notes)
- Share class statistics about the usage of digital tools compared to the individual's usage

Create customization in the reading format to account for individual differences.

Students show individual differences in reading behaviors when reading digital text based on prior digital reading experience and prior knowledge of the topic (Grossnickle Peterson & Alexander, 2020). Students who relied on deeper processing behaviors (by engaging in re-reading and questioning) showed greater digital reading performance than those who read linearly through the text or who selectively chose sections to attend to (Trakhman, Alexander, & Silverman, 2018). Reading aids can train students to focus on the right material and improve reading comprehension scores (Lauterman & Ackerman, 2014). Personalized feedback within the digital reading material may improve reading skills and improve motivation (Goodwin et al., 2020).

Design Recommendations
- Track students reading behaviors (reading time, comprehension problem areas)
- Present personalized feedback to improve reading skills

Detect mindless reading by introducing reading "check-in's" that assess comprehension

Students report that reading for class is difficult due to increased distractions within the content and in the learning environment (Sage et al., 2019). Students tend to skim and skip across pages more in a digital text compared to a print text, likely due to a lack of cognitive engagement with the material (Johnston & Ferguson, 2020). Non-disruptive, integrated reading "check-in's" can encourage students to stay motivated while reading and promote limiting distractions within the learning environment (Nichols, 2020).

Design Recommendations
- Embed reminders or timers to improve focus during reading time
- Embed suggestions to decrease digital distractions (i.e. silence phone, close other screens)

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