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INVITED COMMENTARY

Toward a Multifaceted Heuristic of Digital Reading to Inform Assessment, Research, Practice, and Policy

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ABSTRACT

In this commentary, the author explores the tension between almost 30 years of work that has embraced increasingly complex conceptions of digital reading and recent studies that risk oversimplifying *digital reading* as a singular entity analogous with reading text on a screen. The author begins by tracing a line of theoretical and empirical work that both informs and complicates our understanding of digital literacy and, more specifically, digital reading. Then, a heuristic is proposed to systematically organize, label, and define a multifaceted set of increasingly complex terms, concepts, and practices that characterize the spectrum of digital reading experiences. Research that informs this heuristic is used to illustrate how more precision in defining digital reading can promote greater clarity across research methods and advance a more systematic study of promising digital reading practices. Finally, the author discusses implications for assessment, research, practice, and policy.

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In 2003, as a budding researcher studying the nature of online reading comprehension, I was convinced that the literacy community needed to expand its understanding of reading comprehension to reflect the skills, strategies, and dispositions required to engage with and make sense of information on the internet. Drawing on the well-articulated model of reading comprehension outlined in the RAND Reading Study Group's (RRSG; 2002) report, I made the case for broadening our understanding of four elements—the text, the reader, the reading activity, and the social context—to encompass both traditional comprehension practices (e.g., determining important ideas, making inferences, evaluating, synthesizing) and fundamentally new reading practices prompted by the internet (see Coiro, 2003). More specifically, I argued,

the Internet provides opportunities for interacting with new text formats (e.g., hypertext and interactive multiple media that require new thought processes); new reader elements (e.g., new purposes or motivations, new types of background knowledge, high-level metacognitive skills); and new activities (e.g., publishing multimedia projects, verifying credibility of images, participating in online synchronous exchanges). Likewise, the Internet expands and influences the sociocultural context in which a reader learns to read by providing collaborative opportunities for sharing and responding to information across continents, cultures, and languages. (p. 459)

At the time, there were few empirical findings to support these claims. Consequently, I pointed readers to illustrative examples of digital texts and online practices to demonstrate how conventional understandings of the reader, the text, the activity (or task), and the context were not always applicable in electronic and networked environments. Seventeen years later, in 2020, a large body of theoretical and empirical work supports these claims, as I detail throughout this commentary. Collectively, this work has the potential to increase the precision and rigor of

research around digital reading and clarify dimensions of online reading comprehension for educators seeking to foster productive digital literacy practices in their classrooms.

Importantly, although there is growing evidence to support that variations in readers, texts, tasks, and contexts indeed influence digital reading comprehension, there is far less agreement about the terms used to define, describe, and compare digital reading practices within and across studies. In fact, Singer and Alexander (2017b) pointed to the “lack of conceptual clarity and specificity within the educational literature” (pp. 1009–1010) as justification for their literature review examining how print and digital reading has been defined over the past 25 years. Indeed, their findings showed that only five of 36 empirical studies included a definition of digital reading in any form, and only two of those 36 studies included an explicit definition of digital reading.

Similarly, there has been little consistency in how different scholars operationalize digital reading. For example, to conduct their systematic review, Singer and Alexander (2017b) defined digital reading as “reading involving hypermedia technology” (p. 1011). Elsewhere, digital reading has been conceptualized as reading on a digital screen (Baron, 2017; see also Tanner, 2014), which in some cases has been operationalized as a unitary construct that involves reading unpaginated PDF texts on a computer screen (Mangen, Walgermo, & Brønnick, 2013). Other scholars (Salmerón, Strømsø, Kammerer, Stadtler, & van den Broek, 2018) have conceptualized digital reading as a multidimensional construct involving both the application of navigation, integration, and critical evaluation processes and how these processes interact with individual differences, task differences, and variations of digital reading interfaces. Still others have situated definitions of digital reading along a spectrum between the endpoints of reading single digital texts and reading in highly interactive environments; “between these endpoints are

conceptualizations of reading in digital environments such as the reading of multiple texts in traditional formats, non-interactive activities as reading for entertainment or for information-gathering on the internet, and so on” (Barzillai, Thomson, Schroeder, & van den Broek, 2018, p. vii).

In this commentary, I posit that although there are multiple ways to view the rapid changes in literacy emerging from new technologies (Coiro, Knobel, Lankshear, & Leu, 2008; Labbo & Reinking, 1999), it is imperative that we work to establish both clear and ecologically valid descriptions about what the term *digital reading* encompasses in order to better leverage research findings in ways that directly impact policy, practice, and future research. More specifically, I aim to bring to light a number of tensions and research trends emerging from a rapidly shifting and continually growing landscape of digital literacy practices. First, I highlight the work of numerous scholars who have recommended that we not only recognize but also embrace the complexity of digital literacy in all of its diverse forms. I also clarify my own use of the terms *digital literacy* and *digital reading* for this commentary. Next, I provide a historical glimpse into the work of scholars who, for almost 30 years, have grappled with how to characterize the changing nature of reading in the larger context of digital literacy practices. Then, I introduce several empirical studies to provide evidence that contemporary researchers have continued to overemphasize the medium of text delivery while ignoring variations in other factors also likely to influence comprehension performance in digital spaces. Finally, to point the way forward, I propose a multifaceted heuristic of four increasingly complex factors to characterize the diverse nature of reading comprehension in digital spaces (see Figure 1), and synthesize findings from a considerably large body of scholarship in line with these ideas.

INSERT FIGURE 1 ABOUT HERE

Importantly, I envision the terms and related practices within this heuristic not as a definitive set of reading-related concepts but as a starting place from which to promote rich public conversation about what we currently know about digital literacy practices and how that knowledge can be used to characterize, measure, teach, and support comprehension across a range of digital reading contexts. Overall, this commentary is a call to more explicitly define the range of experiences that may be conceived of as digital reading or risk losing insights gained from almost three decades of research.

What Is Digital Literacy?

In 2018, *Education Week* issued *Special Report: The Changing Face of Literacy*. The purpose of the report was to spotlight scholar and practitioner perspectives of what digital literacy means for schools and what literacy skills learners need for success in the workplace. In the first featured article, titled “What Is Digital Literacy?,” Heitin (2016) pointed out that “while the word ‘literacy’ alone generally refers to reading and writing skills, when you tack on the word ‘digital’ before it, the term encompasses much, much more” (p. 2). Then, to support her claim, she clustered views of several digital literacy scholars into one of three dimensions: finding and consuming digital content, creating digital content, and communicating or sharing digital content.

With respect to the first dimension, finding and consuming digital content, Heitin (2016) highlighted work by Donald Leu, who has distinguished the practices that readers use to engage with static text (on paper or on the screen) from more interactive and potentially challenging digital reading practices, such as querying search engines, navigating hyperlinks, and negotiating dynamic images (see also Leu, Kinzer, Coiro, Castek, & Henry, 2013, 2018). Similarly, building on variations in how different readers interpret the same text (see Rosenblatt, 1978), Troy Hicks

has elaborated on the challenges posed by digital texts with multiple pathways that are “designed so that no two readers experience [those texts] in the exact same way” (Heitin, 2016, p. 2).

Heitin (2016) highlighted a second group of scholars, including Renee Hobbs, who have viewed digital literacy as moving beyond how learners consume information to also encompass the literacy practices that readers use to turn their knowledge into action through critical media literacy and collaborative content creation (see also Hobbs, 2017). According to this view, digital reading and digital authorship may be conceived as reciprocal digital literacy practices (Coiro & Hobbs, 2017) in much the same way that print-based reading and writing experiences involve interconnected acts of composing (Tierney & Pearson, 1983).

A third dimension of digital literacy focuses on how individuals use technologies to communicate or share content, which may or may not be connected to digital reading. According to Heitin (2016), Spires and Bartlett, for example, suggested that “Web 2.0 tools are social, participatory, collaborative, easy to use, and are facilitative in creating online communities” (p. 2; see also Spires & Bartlett, 2012). More recently, Spires, Himes, Paul, and Kerkhoff (2019) extended their understanding of digital literacy practices as ways of sharing to encompass the cosmopolitan literacies useful for digital, cross-cultural exchanges around global themes such as poverty and climate change. Still other scholars in the *Education Week* (“Special Report,” 2018) spotlight have described digital communication practices more aptly with terms such as *digital coding*, *digital citizenship*, and *digital storytelling*.

At least two important ideas emerged from my reflection about the content and structure of Heitin’s (2016) curated attempts to define digital literacy. First, it is clear that there are multiple, diverse, and overlapping conceptions of digital literacy among literacy scholars and educational practitioners; each conception is worthy of focused study and further discussion.

Second, it is important to note how Heitin clustered views of digital literacy into three dimensions; this helps readers not only characterize what is similar about each scholar's unique perspective but also concretely differentiate one dimension of digital literacy from another. As Heitin explained, "the term [*digital literacy*] is so broad that some experts even stay away from it, preferring to speak more specifically about particular skills at the intersection of technology and literacy" (p. 2). It is the particularity of this broad set of competencies, especially those that reflect digital reading, that I believe needs more attention.

In this commentary, I use the terms *digital literacy* and *digital reading*. *Digital literacy* is used to conceptualize digital reading in the broader framework of reading as literacy that involves a process of integration and construction situated in social and cultural practices (see Frankel, Becker, Rowe, & Pearson, 2016). A framework of digital literacy helps emphasize that digital reading is enacted in particular contexts, while also reflecting how many literacy scholars have situated their own research involving digital technologies. Later, I use the term *digital reading* to draw attention to studies particularly focused on reading comprehension and the varied dimensions likely to influence comprehension performance in digital spaces. A framework of digital reading sets the context in which to propose a multifaceted heuristic that directly reflects these ideas. A focus on digital reading also helps explain why other digital literacy practices (e.g., digital writing and composition) do not receive equal amounts of attention in this commentary. Finally, in line with others who have acknowledged a spectrum of reading practices in digital environments, I define digital reading as a range of multifaceted meaning-making experiences whereby readers engage with multiple texts for particular purposes that are situated in diverse contexts. Each experience can then be operationalized more

specifically to characterize how one digital reading experience is similar to and different from another.

Thus, in this commentary, I put forth two claims. First, I make the case that researchers in the literacy community need to engage in efforts to more specifically define and operationalize particular terms that most align with varied views of digital reading, especially those that involve sets of multifaceted practices linked to consuming, making sense of, creating, and using digital content. Second, I argue that more attention needs to be paid to how to more clearly articulate the complex variations in readers, texts, activities, and contexts that research has suggested are likely to influence performance in digital reading comprehension. Only then can we expect to more validly capture and document changes in elements that influence or serve as outcomes of reading in digital spaces.

A Shifting Landscape of Digital Literacy Practices and Perspectives

From my perspective, much of the literacy community's focus on digital literacy began with ideas put forth in the first volume of the *Handbook of Literacy and Technology: Transformations in a Post-Typographic World* (Reinking, McKenna, Labbo, & Keiffer, 1998). This book's subtitle captures the essence of its premise, which was to advance thinking about how to characterize reading and writing in a world in which printed texts are no longer dominant. In the Introduction, Reinking (1998) proposed that "the transformations of literacy that are beginning to become evident are major threads running through the fabric of daily life" (p. x), including facets of law, media, government and international relations, economics, and communication. Fueled by national efforts to improve literacy in elementary and secondary schools (see Alvermann & Guthrie, 1993), authors in this handbook were driven by a concern for the educational implications of these literacy transformations, as well as their vision "that digital forms of

reading and writing represent a powerful stimulus for transforming educational structures and practices” (Reinking, 1998, p. xi).

Of critical importance in this handbook was Reinking’s (1998) careful efforts to introduce and deconstruct, at length, key terms such as *literacy*, *technological*, *transformations*, and *post-typographic* before launching into chapters that provide evidence of at least six ways that literacy might be transformed by new digital technologies: technological transformations affecting texts, readers and writers, schools and classrooms, instruction, society, and literacy research. Reinking’s careful deconstruction of these terms enabled the literacy community to study changes in these concepts moving forward. He also put forth four conclusions across the 20 chapters that sound surprisingly relevant even in today’s context:

1. “Electronic and printed texts are qualitatively different” (p. xxiv).
2. “There is an important sociocultural and historical dimension to considering the relation between technology and literacy” (p. xxv).
3. “The new technologies of electronic reading and writing are slowly but steadily transforming classrooms, schools, and instruction” (p. (xxv).
4. “There is a dearth of research and scholarship available to understand and guide technological transformations of literacy” (p. xxvii).

Although these ideas were compelling in 1998, I find it frightfully telling that the very same ideas merit attention more than 20 years later, as rapid technological transformations continue to challenge our ability to define and understand the nature of literacy and the implications of these changes for policy, practice, and research. Of course, despite these challenges, the literacy community has tried to keep pace with efforts that inform work in these arenas.

For example, in their report, *Reading for Understanding: Towards an R&D Program in Reading Comprehension*, members of the RRSg (2002) recognized that “we now live in a society that is experiencing an explosion of alternative texts” (p. xv). Later in their report, they explained, “electronic texts that incorporate hyperlinks and hypermedia introduce some complications in defining comprehension because they require skills and abilities beyond those required for the comprehension of conventional, linear print” (p. 14). Unfortunately, the report included little beyond these statements to more clearly articulate the nature of these complications and related skills and abilities. Nevertheless, I have argued (see Coiro, 2003) that the report’s developmental heuristic of reading comprehension provides a solid framework from which to organize, expand, and characterize variations in literacy introduced by continually transforming technologies.

This heuristic includes three elements:

- The *reader* who is doing the comprehending
- The *text* that is to be comprehended
- The *activity* in which comprehension is a part. (RRSG, 2002, p. 11)

Moreover, these three elements occur within the sociocultural context of the reader’s classroom, home, and neighborhood, and they help the reader interpret information and create personal meaning. I still believe, as I wrote in 2003, that we need to continue to broaden our conceptions of each element in the RRSg heuristic because

some tasks on the Internet ask readers to extend their use of traditional comprehension skills to new contexts for learning, while others, like electronic searching and tele-collaborative inquiry

projects, demand fundamentally different sets of new literacies not currently covered in most language arts curriculums. (Coiro, 2003, p. 463)

Empirical evidence provided later in this commentary supports these claims.

A few years after the RAND report, the second volume of the handbook was published, aptly titled *International Handbook of Literacy and Technology* (McKenna, Labbo, Kieffer, & Reinking, 2006). This volume further expanded the conversation around technology and literacy to a broader, and more international, circle of authors and issues. Of note, although not explicitly intended as such, the organization of the book's table of contents appears to reflect particularized applications of literacy and technology in line with the variations in readers, texts, activities, and contexts proposed in the RRSg's (2002) report. That is, sections of the handbook were devoted to (a) unique digital applications with specific populations of readers; (b) digital dimensions of literacy activities and texts designed to foster emergent literacy, comprehension, fluency, spelling, vocabulary, writing, and family literacy; (c) digital practices designed for diverse purposes (e.g., teacher education, professional development, student engagement); and (d) unique applications of literacy practices within diverse contexts such as digital software and the internet.

In his discussion of these chapters in the Introduction of the handbook, McKenna (2006) reiterated the continued tensions between print and digital environments and described "an uneasy coexistence" (p. xvi) of print and digital reading contexts. Moreover, McKenna concluded with an important reminder that we should continue to take heed as we venture forward:

The most prudent view is not to view these transformations as transitions from one static state to another, but to perceive them as an unending evolution. We must learn that where literacy and technology converge, our principal concern should be the journey, not the destination. (p. xvii)

To that end, the heuristic of digital literacy experiences that I propose later in this commentary is intended to open the door to a common language that may help guide our journey while remaining flexible to changes that will continue to redefine reading comprehension in a digital world.

Several other large and occasionally overlapping bodies of work have informed, and are likely to continue to inform, our understanding of digital literacy. Three areas of scholarly work are the tradition of New Literacy Studies, a new literacies perspective of online reading comprehension, and models of multiple-document comprehension. Efforts put forth by professional organizations and assessment practices also inform our thinking. Below, I briefly synthesize changing conceptions of digital literacy in line with each area.

New Literacy Studies

Rooted in sociocultural traditions (Barton, Hamilton, & Ivanič, 2000; Street, 2003) of everyday, print-based literacy practices and New Literacy Studies (Gee, 1990), the New London Group (1996) shared their vision of a new approach to literacy pedagogy designed to create equal life chances for all students to benefit from learning. This vision is encompassed by a pedagogy of multiliteracies that seeks to leverage “the multiplicity of communications channels and media, and the increasing saliency of cultural and linguistic diversity” (p. 63) in society. From this perspective, literacy can and should serve to empower learners as social designers who actively question power structures and design more equitable and fulfilling aspects of work, community, personal life, and learning. Following the publication of this manifesto, the New London Group

joined with other authors to issue a call for broadened understandings of language-based texts to encompass multiple modes of meaning making that “differ according to culture and context, and have specific cognitive, cultural, and social effects” (Cope & Kalantzis, 2000a, p. 5). In the collection of essays titled *Multiliteracies: Literacy Learning and the Design of Social Futures* (Cope & Kalantzis, 2000b), various scholars discussed, among other topics, the effects of technological change on conceptions of literacy, teaching, and the role of schools.

More recently, Mills (2010) documented the significant digital shift in New Literacy Studies, in what she labeled “the ‘digital turn’—that is, the increased attention to new literacy practices in digital environments across a variety of social contexts, such as workplaces and educational, economic, and recreational sites” (pp. 246–247). Mills’s review uncovered many promising practices as she synthesized a decade of largely ethnographic studies investigating a wide range of digital literacy practices across in-school, after-school, and out-of-school contexts, as well as efforts to connect literacy practices across home and school settings. Mills also highlighted difficulties in defining and “limiting what constitutes ‘literacies’ in a changing communications environment” (p. 250) while pointing to the increasing role of digital technologies as necessitating a broader conception of texts across multiple modes, “opening up a wider range of meaning potential” (p. 251). Among her recommendations was a call to reform conventional, print-based performance indicators by defining and disseminating innovative models of digital and multimodal reading for these new times. In addition, she argued for an increase in design-based research methodologies that promote formative, flexible, and contextually situated conceptions of what counts as digital literacy.

Over the years, Lankshear and Knobel (2003, 2006, 2007, 2011) have also kept researchers and practitioners abreast of the rapidly evolving new literacies and social practices

that accompany changes in technology from the lens of New Literacy Studies. Mills (2016) has continued to push the field to consider new lenses (e.g., social, critical, multimodal, spatial, material, and sensory theories) that further broaden our understanding of digital literacy practices. Finally, Serafini and Gee's (2017) publication brought together literacy scholars to celebrate the 20th anniversary of the New London Group's (1996) manifesto. Serafini and Gee's edited collection skillfully synthesizes the varied, complex, and still evolving ways that literacy scholars imagine the future of multiliteracies pedagogy and its implications for literacy education. Surely, these variations and complexities should be represented in our conceptions of digital literacy moving forward.

A New Literacies Perspective of Online Reading Comprehension

Scholarship in New Literacy Studies is not to be confused with another community of researchers (myself included) who argue that "new technologies such as the Internet and other ICTs [information and communications technologies] require additional social practices, skills, strategies, and dispositions to take full advantage of the affordances each contains" (Leu et al., 2013, p. 1159). Although Leu and colleagues (2013) supported work focused on how technology impacts everyday and out-of-school literacies, they also claimed that not enough attention has been paid to understanding how individuals develop and demonstrate the literacies needed to read and use online informational texts in formal school and work settings. In that context, research grounded in a new literacies perspective of online reading comprehension defines online reading comprehension as "a self-directed process of constructing texts and knowledge while engaged in several online reading practices: identifying important problems, locating information, critically evaluating information, synthesizing information, and communicating information" (Leu et al., 2013, p. 1163). Similar to print-based reading experiences,

comprehension in internet-based reading contexts can take place individually but often appears to be enhanced when it takes place collaboratively.

Early quantitative research grounded in this more social constructivist definition of new literacies suggests that both print-based and digital reading comprehension skills make significant and independent contributions to online reading performance across different contexts (Coiro, 2011). Elsewhere, Coiro and Dobler (2007) found that different digital reading purposes and contexts (e.g., reading a list of search engine results vs. reading within a multilevel website) appear to elicit different cognitive reading processes and varied sources of prior knowledge that will be important to operationalize in future studies. Similarly, variations in digital reading contexts, such as working individually versus working with a partner in face-to-face or remote conditions, introduce additional features that appear to influence the quality of comprehension and/or decision making during online inquiry (Coiro, Castek, & Guzniczak, 2011; Kiili, Coiro, & Rääkkönen, 2019). For example,

the lack of familiarity with real-time collaborative environments...and working and talking together remotely in a digital platform with someone you have not met previously may introduce additional challenges beyond working and talking together with someone new in more familiar face-to-face situations. (Coiro et al., 2019, p. 287)

Other studies of digital reading comprehension have suggested that the processes used by skilled readers to comprehend online text are both similar to and more complex than what previous research has suggested is required to comprehend offline informational text (see, e.g., Afflerbach & Cho, 2009; Kingsley & Tancock, 2014). “The accumulation of many small and large differences of frequency, degree, and speed has indeed produced a qualitative change and a new kind of cognitive challenge for comprehending online” (Hartman, Morsink & Zheng, 2010,

p. 132). Still other theoretical collections of new literacies (e.g., Baker, 2008) and more practice-based classroom applications of new literacies (e.g., Dobler & Eagleton, 2015; Moss & Lapp, 2009, 2010) have provided us with a solid grounding from which to consider direct implications of new literacies for teaching, learning, assessment, and professional development. Across this body of work, as is the case with print-based reading comprehension (RRSG, 2002), variations in readers, texts, activities, and contexts continue to reveal themselves as playing an important role in how meaning is constructed in digital spaces.

Models of Multiple-Document Comprehension

A third area of scholarship that informs our understanding of digital literacy, and digital reading in particular, is that of multiple-document comprehension (Goldman, Lawless, & Manning, 2013; Rouet & Britt, 2011). Scholars in this arena have recognized the diverse reading practices required to interpret a variety of task purposes, select relevant and reliable digital sources, analyze and integrate information within and across multiple print and digital documents, and then apply this information to achieve specific task goals.

Yet, even within this relatively narrow scope of consuming and using information as a set of digital reading practices, researchers have grappled with defining the complexities of multiple-source use, or the ability to select, process, and use information from multiple information sources (see Braasch, Bråten, & McCrudden, 2018). As such, Braasch and colleagues (2018) made the case for presenting research involving multiple-source use in a manner that accurately reflects conceptions of sourcing that vary from general to more specific. Further, they were hopeful that efforts toward conceptual clarity will help promote a common language from which to systematically study and draw conclusions across different lines of research about “when, how, and why readers use multiple sources” (p. 5). Informed and inspired

by this agenda, I propose that parallel efforts should be made among those seeking to understand the nuanced complexities of digital reading, in all of its varied forms and platforms, in order to more systematically study and draw conclusions about the impact of technology use on reading comprehension.

Digital Reading and Professional Organizations

In line with developments in literacy theory and research, professional organizations also have recognized the increasingly varied and digital nature of reading. Their perspectives are important (and hence belong in a review of theoretical and empirical scholarship about digital reading) because professional organizations will be the catalysts in transforming our research findings into practices, outreach, and professional development that will bring scholarship into formal and informal educational settings.

Both the International Literacy Association (International Reading Association, 2002) and the National Council of Teachers of English (2019) have recognized the multiple, dynamic, and malleable literacies required to locate, manage, analyze, critique, evaluate, synthesize, curate, collaborate, design, create, share, and publish texts in digital spaces for the purposes of solving problems and strengthening independent thought. Both organizations also have emphasized the importance of working collaboratively and advocating equitable access as part of digital reading and learning. Similarly, the American Library Association (2013) has continued to expand their definition of both cognitive and technical digital literacy skills as part of efforts to promote teaching and learning in a digital age. Most recently, the American Library Association's sister organization, the American Association of School Librarians (2018; AASL), issued its "AASL Standards Framework for Learners," which characterizes digital literacy skills across a matrix of six integrated frameworks (inquire, include, collaborate, curate, explore, and

engage) and four domains (think, create, share, and grow). Across these elements, the AASL authors proposed that “reading is the core of personal and academic competency” (p. 3). With developments like these being issued by several professional organizations, today’s students and teachers deserve more clarity in how to articulate the varied dimensions of digital reading and how each may promote or complicate learning and problem solving in a digital age.

Digital Reading and Large-Scale Assessments

Finally, frameworks and items on national and international assessments have begun to reflect more complex and particularized conceptions of reading in digital spaces. In 2017, the National Assessment of Educational Progress (NAEP) reading framework included an expanded definition of reading to include digital elements as part of “using meaning as appropriate to type of text, purpose, and situation” (National Assessment Governing Board [NAGB], 2017, p. 2). This change made it possible to operationalize the framework’s definition of reading more fully through the introduction of digital elements that were not possible in the paper assessment.

Between 2016 and 2018, NAEP included a piloted series of digitally based reading assessments with a small sample of students and formally administered digital assessments in civics, geography, U.S. history, and technology and engineering literacy (National Center for Education Statistics, 2019). (Sample questions and item maps may be viewed at <https://nces.ed.gov/nationsreportcard/about/booklets.aspx>.) Researchers have begun to notice how digital literacy may likely play a role in performance on these assessments of diverse disciplinary knowledge (see, e.g., Morsink, 2019). Large-scale implementation of digital reading assessments that incorporate dynamic texts, videos, animation, and innovative item types and formats occurred in 2019 (National Center for Education Statistics, 2019). A clear articulation of features that characterize varied digital texts, activities, and purposes and how these features

interact in different assessment situations and with different readers will be critical to the success of future large-scale efforts like these.

Notably, OECD's (2015) Programme for International Student Assessment of digital reading provides a tangible starting place for how to operationalize digital texts and digital reading activities. OECD's framework "treats digital and print reading as a single domain, while acknowledging the differences between reading on paper and reading on digital platforms" (p. 83). Thus, assessment items are designed to reflect differences in texts and tasks in print and digital reading mediums. In addition, OECD's digital framework puts less emphasis on narrative texts while recognizing the prevalence of informational, personal communication, and "transaction texts" (p. 83) designed to achieve a specific purpose in digital reading spaces.

Further, the OECD (2015) framework authors explained how digital texts introduce additional complexities to a number of digital reading activities. These complexities make it harder for learners to perform at least three kinds of reading tasks: access and retrieval tasks, which require use of searching skills in more abstract spaces; integrate and interpret tasks, which require more reliance on short-term memory to simultaneously read across multiple documents; and reflection and evaluation tasks, because fewer filters demand critical reading skills to establish the credibility of content needed to solve even simple reading tasks. Here, we begin to see complex overlaps among texts, activities, and reading purposes that have implications for comprehension.

Finally, whereas current NAEP assessments intentionally minimize reading tasks that require navigation skills to maintain alignment with its current definition of reading, OECD's (2015) report includes a chapter devoted to findings that highlight the importance of navigation as part of online reading. The OECD authors argued that

knowledge of some techniques of navigation and some navigation tools (e.g. hyperlinks, tabs, menus, the ‘back’ button) are part of being literate in the digital medium. Such skills and knowledge should be regarded as ICT skills that are measured, together with the mastery of reading processes, in the assessment of digital reading. (p. 84)

Other assessments are designed to measure naturally reciprocal digital literacy processes in the context of application tasks that integrate the consumption (reading), production (writing/creation), and communication (sharing, presenting, and publishing) of multimedia texts in digital platforms. This distinction is important for developing assessments that measure not only comprehension but also what one can do with the fruits of one’s comprehension. Items on Learning.com’s (n.d.) Digital Literacy Assessment, for example, are designed to assess a complex range of learning targets aligned with the International Society for Technology in Education’s Standards for Students, which include students’ ability as knowledge constructors able to plan, explore, locate, and curate meaningful connections between ideas; innovative designers able to test and refine their research process while creating innovative artifacts and solving authentic problems; creative communicators able to repurpose, remix, create, publish, or present ideas; and global collaborators able to connect and engage with others constructively and collaboratively while working toward a common goal.

A final series of assessments that indicate the definition of digital reading is expanding in diverse and particularized ways are those that highlight collaboration and social deliberation as part of meaning construction in digital spaces (for a review, see Coiro, Sparks, & Kulikowich, 2018). These assessments emphasize cognitive and social skills required for successful comprehension (e.g., Sabatini, O’Reilly, & Doorey, 2018) and collaborative problem solving (e.g., Griffin & Care, 2015; OECD, 2017). Some assessments are designed to tap integrated

performances spanning multiple digital literacy competencies, such as locating, evaluating, and synthesizing information across multiple documents and writing a source-based argumentative essay (see Coiro et al., 2019). Others involve the sequencing or decomposition of digital reading tasks (e.g., identifying multiple perspectives, judging source reliability), which permits estimations of proficiency with or relations among key reading components such as literal comprehension, inference generation, summarization, or reasoning about text information (e.g., Goldman et al., 2019; Sabatini, O'Reilly, Halderman, & Bruce, 2014).

Both types of assessments provide psychometrically strong exemplars of how to operationalize multiple digital reading competencies and related learning targets as part of collaborative problem solving. In addition, both types of assessments are ecologically valid reminders that digital reading can involve multiple and varied numbers of readers and diverse types of texts, activities, purposes, and contexts. Clearly, across the current landscape of scholarly work, a vague and narrow definition of digital reading as a singular practice that one individual engages in on one type of digital device will not suffice.

Tensions in the Study of Digital Reading

To address the call for more research that embraces the complexity of digital reading, it might be argued that there has been little scholarly work to inform our understanding of digital reading and key indicators likely to influence comprehension. Yet, this is not the case, as I illustrate in the remainder of this commentary. Indeed, almost 30 years ago, Dillon (1992) highlighted the challenges of determining how to validly measure comprehension, in an extensive and critical review of empirical studies published between 1977 and 1991. Even then, however, Dillon identified more than 18 areas in which to classify issues to deal with the precise nature and extent of differences between reading from paper and reading from screens; many related to

differences in text, activity, reader, or context. These included possible differences in outcomes such as speed, accuracy, fatigue, comprehension, and preference, as well as process differences related to eye movements, manipulation (i.e., turning pages, browsing contents of a document), and navigation. Even as hypertext features in electronic texts were just beginning to emerge, Dillon pointed out the shortcomings of research that limited and distorted reading by controlling so many variables that the resulting “task bears little resemblance to the activities most of us routinely perform as ‘reading’” (p. 1322).

Despite the prevalence of scholarship highlighting the complexity of digital reading, and recommendations for studies involving more authentic digital reading practices, researchers have continued to limit large empirical studies to those that emphasized the medium of text delivery (print or digital) rather than moving toward the hard work of conceptualizing and measuring the wide range of outcome and process-based indicators likely to impact comprehension performance in a digital world. For example, in one year alone, amid the explosion of hypertext and internet use in school (Rainie, 2005), three large meta-analyses were limited to studies with controlled experiments comparing performance on narrowly defined reading activities (e.g. standardized reading tasks, surveys, adaptive testing situations) administered on paper or on-screen (see Kingston, 2008; Noyes & Garland, 2008; Wang, Jiao, Young, Brooks, & Olson, 2008). Of note, findings across all three reviews showed that differences in test format and content (texts and activities) rather than differences in the medium itself predicted reading outcomes. Moreover, the authors concluded with recommendations to explore additional potential moderators in order to compare comprehension across different reading contexts.

Unfortunately, almost a decade after these meta-analyses were published, more contemporary researchers still continued to narrow the scope of their reviews to studies in which

readers engage with comparable texts on both paper and on a digital screen rather than to systematically review studies exploring the complexities of readers engaging with diverse digital texts and tasks. For example, in their review of 25 years of work exploring digital reading, Singer and Alexander (2017b) excluded any study of digital reading that did not measure comprehension performance in both print and digital texts. In another meta-analysis exploring effects of reading media on reading comprehension in studies published between 2000 and 2017, Delgado, Vargas, Ackerman, and Salmerón (2018) confined their search procedures to studies comparing the reading of comparable texts on paper and digital devices, or “texts displayed on digital screens, including computers, tablets, mobiles phones, and e-readers” (p. 26). Delgado and colleagues chose to exclude specific features of digital environments such as hyperlinks and web navigation so reading materials “were comparable across media in terms of text content, structure, and presence of images” (p. 26).

A third meta-analysis of 17 studies dating from 2000–2016 was also limited to studies that compared differences between reading on screen and reading on paper in the same study (Kong, Seo, & Zhai, 2018). Other widely cited studies were confined to comparing outcomes after reading two texts in print to reading the same two texts on a computer screen as PDFs (Mangen et al., 2013) or those comparing differences in comprehension when students read both digital and print versions of newspaper articles and book excerpts on a researcher-defined topic (Singer & Alexander, 2017a). Like other researchers, to control for differences across the texts, Singer and Alexander (2017a) employed a very narrow definition of digital reading, limiting their selection of digital texts to those that were “fully available to readers” (p. 157; i.e., did not include hyperlinks or require scrolling).

Findings from these studies point to some advantages in comprehension when reading paragraphs of static text on paper as compared with reading comparable text on a computer or other type of digital device. Collectively, these studies provided important information about print- and screen-based differences when reading static paragraphs of text. Yet, large-scale efforts that simplify the challenges inherent in digital reading and response impede our understanding of other authentic digital reading practices moving forward (Seaboyer & Barnett, 2019; Wolf & Barzillai, 2009). Future research efforts must now focus on naming, defining, categorizing, and researching other indicators beyond the medium of text delivery that are likely to influence comprehension processes and outcome measures in digital reading contexts.

Patterns Emerging Across Studies of Digital Reading

As literacy scholars continue to study the nature of digital reading, at least three important ideas can inform the work that lies ahead. First, numerous studies have confirmed that digital reading involves complex and overlapping comprehension processes, such as navigation, evaluation, and integration, that are influenced by individual differences in competence and motivation, the design of digital reading interfaces, and differences in task and purpose (e.g., Cho, Woodward, Li, & Barlow, 2017; Coiro & Dobler, 2007; Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Kiili et al., 2019; Salmerón et al., 2018). In some ways, these processes are similar to those of print-based reading, but we can no longer ignore new digital reading competencies that need to be clearly defined. Wolf (2010), who highlighted the extraordinary range of processes involved in traditional paper-based reading, advised that to leverage the potential of digital text, we must now “bring our best thought and research to preserving what is most precious about the present reading brain, as we add the critically important new capacities of its next iteration” (p. 40). In fact, “the medium itself may provide us with new ways of

teaching and encouraging young readers to be purposeful, critical, and analytical about the information they encounter” (Wolf & Barzillai, 2009, p. 36).

Second, we know that reading competently across digital spaces requires the ability to effectively move back and forth across multiple media, modes, purposes, and contexts. That is, digital reading demands skills in using and producing media, or what is known as multimediating (Doneman, 1997; see also Lankshear & Knobel, 2003), in addition to what Wolf (2018) coined as *biliteracy*, or the ability to shift between reading for information that involves browsing, linking, and scanning with efficiency and the deep, reflective reading that happens when readers slow down and think more critically. Seaboyer and Barnett (2019) highlighted the importance of fostering the coexistence of expertise for both reading purposes. Ultimately, our conception of digital reading should encompass both cognitive and affective purposes for reading that merge social and academic settings (Moje, Dillon, & O’Brien, 2000; O’Brien & Bauer, 2005).

Third, Alexander and the Disciplined Reading and Learning Research Laboratory (2012) reminded us that reading competence in the 21st century is multidimensional, developmental, and goal directed. Moving forward, it is imperative that we blend diverse perspectives of reading to rightfully acknowledge “the expanded number of contextual nuances, knowledge sources, and interactive elements observed during each unique online reading experience” (Coiro, 2015, p. 58). Thus, it makes sense to embrace digital reading in all of its complexities, finding ways to emphasize attributes that remain constant while also allowing for flexibility in how these attributes are combined and reimagined as one digital reading practice transforms into others. These efforts will enable the literacy community to build on the transformative nature of reading recognized more than 20 years ago (Reinking, 1998) while attempting to integrate the dramatic changes likely to emerge in the next 20 years.

Amid the complexity, an important challenge becomes what to focus on next. Reflecting on her own review of research involving print and digital reading (see Singer & Alexander, 2017b), Alexander (cited in Sawchuk, 2017) suggested that “it’s not so much a question of a ‘horse race’ between reading in print or reading digitally that needs exploration....Rather, knowing ‘when it matters, for whom, and under what conditions is the question that constantly needs to be examined, again and again’” (para. 5). I agree with Alexander’s proposition.

However, I believe that a more pressing question needs to be answered first: How should we define digital reading in order to validly and reliably determine if and when it matters and for whom? Although there is substantial evidence to support the notion that variations in readers, texts, activities, and contexts may influence reading comprehension, there is far less agreement about the terms used to define and describe digital reading across studies to be able to capitalize on research findings more systematically and achieve clarity on the relative constraints and affordances of various media that readers may encounter in different studies.

Cuban (2018) warned of the dangers of skipping ahead to look at teaching or learning outcomes while using digital technologies before coming to agreement about what is actually being studied; this common agreement is crucial in order to implement treatments and test with fidelity. I propose that the inconsistent results emerging from contemporary studies of how digital reading influences comprehension are partly due to the unspecified variations in reader, text, activity, and context. Consequently, we must decide how to flexibly operationalize digital reading in ways that carry over to multiple studies before we can reliably examine how digital reading practices impact comprehension and learning. Common constructs in any field enable researchers, educators, and policymakers to capitalize on research findings in more systematic ways.

A Multifaceted Heuristic to Characterize the Complexity of Digital Reading

Lauer (2009) made the case that “defining terms is a situated activity that involves determining the collective interests and values of the community for which the definition matters” (p. 225). For this reason, I propose to delineate important terms associated with digital reading as part of a multifaceted heuristic grounded in the reading community’s collective understanding that comprehension in any form or medium involves one or more varied texts, activities, and readers in the context of a particular location and for a particular purpose (RRSG, 2002). Despite the changes to reading since it was first conceived, this four-part heuristic still provides a solid framework from which to organize and flexibly characterize the complex nature of reading comprehension in digital spaces.

In the sections that follow, I aim to summarize contemporary scholarship that has illuminated the diversity of examples within and across elements in a heuristic of digital reading (see Figure 1), while occasionally interjecting evidence-based reminders of the iterative interrelations among the four elements. In the center of the figure, the variety of texts and reading activities is intentionally situated along a circular sequence of examples that increase in complexity as readers move within and across digital mediums. Four categories of reader attributes are used to conceptualize how readers may vary from one another, and four sets of contextual elements serve to characterize the broad variation of situations in which readers may engage with texts and activities as part of any reading experience. Although it is impossible to capture every digital reading experience in one figure, I invite you to appreciate how this four-part heuristic may indeed provide a starting place for flexibly, but systematically,

conceptualizing commonalities and distinctions in how digital reading may vary from one experience to the next.

Text

With respect to textual variations that readers may encounter in today's world, most texts may be classified as literary, informational (NAGB, 2017), or hybrid, which uses a combination of literary and informational text structures (Bintz & Ciecierski, 2017). In the last decade, increasing focus has been placed on comprehending persuasive texts, which put forward a point of view and seek to persuade the reader into taking that proposed view.

Other types of texts include multimedia texts, which convey meaning through text and graphics (Mayer, 2001), and multimodal texts, which “exceed the alphabetic and may include still and moving images, animations, color, words, music and sound” (Selfe, 2007, p. 1).

Although the terms *multimedia* and *multimodal* are sometimes used interchangeably (Moreno & Mayer, 2007), using them separately may help differentiate between multimedia texts that are primarily static (printed words and graphics) and multimodal texts that are more dynamic, in ways that are more typical of digital texts. Dynamic features further complicate the comprehension of multimedia and multimodal texts (Dalton & Proctor, 2008; Magliano, Higgs, & Clinton, 2019). Arrows used to connect ideas in the text region of Figure 1 reflect the increasing complexity that each diverse text type likely introduces to the meaning-making process.

Digital texts, in particular, may be differentiated not only by format or genre but also by where the text is found and how readers engage with the text. Each text type introduces important similarities and distinctions worthy of comparison along a spectrum of text complexity (see also Barzillai et al., 2018). For example, when readers engage with text comparable to that

in a printed format, but the static reading experience takes place on a digital screen, these are called on-screen texts (Baron, 2015; Dillon, 1992). Alternatively, hypertexts are designed to digitally link textual materials and ideas (Burbules & Callister, 2000) in a range of possible interconnections through which readers are able to construct their own personal pathways (Landow, 1994).

Typically, hypertext contains content that is located beneath multiple layers of hyperlinks, navigational buttons, or dynamic image maps, turning hypertexts into hypermedia, which is a digital version of multimedia (Moos, 2014). Hypermedia requires readers to integrate processes for decoding and interpreting images of pictures or video with a repertoire of more foundational comprehension strategies (Kinzer & Leander, 2003). Hypertext and hypermedia comprehension are also influenced by the level of coherence between ideas that readers encounter within and across texts (Salmerón, Cañas, Kintsch, & Fajardo, 2005) and the extent to which organizational devices indicate the underlying structure embedded into hypertext content (Al-Seghayer, 2007).

In this commentary, both *hypertext* and *hypermedia* refer to digitally networked texts found within a closed or bounded digital environment with one organizational structure (e.g., CD-ROM encyclopedias, library databases, digital storybooks). An extension of hypertext has been called *internet text* (Coiro & Dobler, 2007), which refers to hypertexts or otherwise that are found within the open-ended networked system of the internet (Hill & Hannafin, 1997) that changes daily in structure, form, and content (Zakon, 2018). Multimodal internet texts, internet search tools, and animated digital advertisements alongside on-screen static texts create a dizzying array of possibilities for intertextual and multimodal connections and intercultural negotiations across hidden social, economic, and political agendas (Cope & Kalantzis, 2000b).

The combination of multiple text types further complicates how to characterize text as part of digital reading in online spaces (Hartman et al., 2010). Nuanced affordances such as segmentability, juxtaposibility, malleability, multiauthorability, and responsiveness continue to compound the challenges of characterizing digital texts (Hartman & Morsink, 2018).

Finally, augmented reality texts, or those that combine real and computer-generated images in real time, enable readers to engage with digital information (text, audio, video, and 3-D objects) without isolating readers from the physical environment (Tzima, Styliaras, & Bassounas, 2019). In fact, some augmented reality texts integrate video chat and screen-sharing capabilities that enable readers to engage with both the on-screen text and other readers in a different place at the same time (see, e.g., Hardman, 2018). Augmented reality texts are particularly interesting because they bring a continuum of complex texts full circle to exemplify how printed and digital texts can exist in the same space (Hering, 2019). This type of text raises additional questions about how best to characterize digital reading. Thus, in Figure 1, an arrow links augmented text back to literary text to symbolize an overlapping ring of possible text features available in digital spaces.

Surely, in 2020, with the possibility that readers may encounter at least five unique kinds of texts overlapping in a given digital space (on-screen text, hypertext, hypermedia, internet text, and augmented reality text) that may integrate one or more of five traditional text types (literary, informational, hybrid, multimedia, and multimodal), it is no longer valid to suggest that digital reading involves only one kind of text.

Activity

A second element in the RRSg (2002) comprehension heuristic is the reading activity, which entails the purpose, process, and consequences of an activity. Reading activities can be

differentiated as word- and sentence-level activities and those involving single and multiple texts (Britt, Goldman, & Rouet, 2012). Word- and sentence-level reading activities typically involve decoding, reading aloud with fluency and expression, and vocabulary work, such as defining and using words in isolation or focusing on selected words in the context of one or more reading passages. As Rosenblatt (1978) asserted, comprehension activities involving narrative or informational text may be classified for the purpose of efferent reading and response (deriving information from text) or aesthetic reading and response (enjoying a text's characteristics through personal experience and interpretation). NAEP's reading framework (NAGB, 2017) situates comprehension for both efferent and aesthetic purposes in increasingly challenging activities that require readers to locate and recall, integrate and interpret, or critique and evaluate ideas from literary, informational, or persuasive texts.

To complete comprehension activities, readers may engage with ideas found within a single text or ideas located across multiple (two or more) texts, which are sometimes referred to as documents or sources (see Britt et al., 2012). Activities across texts, documents, or sources may be printed, digital, or both, suggesting a direct overlap between reading activity and text type, which further complicates our ability to define comprehension-related activities involving multiple texts (read more in Braasch et al., 2018). At least four models of multiple-document comprehension (see List & Alexander, 2017) have been proposed to describe additional structures and complex mechanisms that account for comprehension in reading situations involving multiple texts. Again, arrows in the activity region of Figure 1 symbolize the increasing complexity likely to characterize each new type of activity.

Comprehension activities in open digital spaces require readers to navigate, evaluate, and integrate ideas that they encounter from narrative or informational hypertext, hypermedia, or

internet text. “In such scenarios, the reader has to cope with (a) the constantly growing number of available information sources, (b) the different formats in which digital information is presented, and (c) the varying quality of the information available” (Salmerón et al., 2018, p. 91). Informational digital reading comprehension activities, in particular, may ask readers to engage with multiple texts to learn more about a topic or to take a position on a set of given conflicting claims (Coiro, Coscarelli, Maykel, & Forzani, 2015). Further, making sense of some online resources involves confirming the credibility of information, whereas other, more one-sided resources may require readers to apply different evaluation practices to question the overall credibility of claims being made (Kiili et al., 2018).

Other reading activities expect readers to not only comprehend but also competently act on new knowledge gained from reading experiences in ways that promote social justice and critical media literacy. These critical media literacy activities (Funk, Kellner, & Share, 2016) typically involve critically analyzing relationships between media and audiences, or information and power, across multiple sources. One example is Mind Over Media (Media Education Lab, 2015), a web-based digital platform with crowdsourcing features that invite readers to exchange ideas about how to recognize, interpret, respond to, and assess the impact of 21st-century propaganda examples in their community.

Online research and inquiry activities (Castek, Coiro, Henry, Leu, & Hartman, 2015; Leu et al., 2013) push readers further into ever-changing open networked environments to identify and then solve problems by searching, locating, evaluating, synthesizing, and communicating in digital and/or nondigital contexts about what they learned. Responses to online research and inquiry activities or even printed reading research activities may lead to digital creation activities, during which readers “gain knowledge and demonstrate competencies by working with

a variety of symbolic systems and a variety of genres to inform, persuade, and entertain target audiences” (Hobbs, 2017, p. 1). At the time of publication, Hobbs (2017) identified at least nine media forms of digital creation: blogs and websites, digital audio and podcasting, images, infographics and data visualization, vlogs and screencasts, video production, animation, remix production, and social media.

As researchers and educators continue to combine and adapt diverse types of texts and activities, unique and specialized reading activities will continue to evolve. Two such examples are digital reading activities that mobilize sound and critical literacy as integral components of digital inquiry (Wargo, 2019) and reading activities that integrate creative T-shirt design with digital inquiry in a makerspace context to promote and practice data literacy skills (Stornaiuolo, 2018). Once again, confining conceptions of comprehension to a simplistic and binary definition of print or digital reading continues to ignore the immense variation of meaning-making activities in which readers are likely to engage across the spectrum of print and digital texts.

Reader

A third element in the RRSg’s (2002) conception of comprehension is that of the reader and differences in variables linked to cognitive capabilities, reading competencies, reading dispositions, and sociocultural identities. These variables may interact with one another and with the texts a reader engages with to influence comprehension performance on a particular reading activity. My earlier argument still applies today as new digital texts and reading activities continue to emerge: “If we expand our definition of...texts [and activities] as previously described, then we must also consider how these texts, and prior experiences with them, compound the variability in readers” (Coiro, 2003, p. 462). Although space does not allow for a comprehensive review in this area here, it is important to recognize how empirical work

continues to broaden our understanding of reader differences while also reaffirming their influence on comprehension as individuals engage with different texts and activities.

Cognitive Capabilities

Much like studies of print-based comprehension, studies of how readers process digital texts (in the context of a particular reading activity) have indicated that variation in at least five cognitive processes influence comprehension in digital spaces. These are the ability to do the following:

- Attend to and remember information (Andresen, Anmarkrud, & Bråten, 2019; Baron, 2017)
- Monitor and self-regulate one's understanding of information (Afflerbach & Cho, 2009; Coiro & Dobler, 2007; Goldman et al., 2012)
- Critically evaluate information for a number of purposes (Barzilai & Zohar, 2012; Bråten, Strømsø & Britt, 2009)
- Integrate and synthesize information (Kiili & Leu, 2019; Salmerón et al., 2018)
- Process information at deep levels (Singer & Alexander, 2017a, 2017b; Wolf, 2018)

Often, researchers have pointed out important relations between one or more cognitive capabilities that influence comprehension. One recent study of 426 sixth graders, for instance, found that skills in nonverbal reasoning (as well as foundational reading skills in word identification, fluency, and written spelling) are correlated with comprehension as predictors of online research and comprehension performance (Kanniainen, Kiili, Tolvanen, Aro, & Leppänen, 2019). In another study, differences in working memory among 44 high school students with and without dyslexia influenced readers' ability to integrate information across multiple webpages and representations (Andresen et al., 2019).

Other researchers have turned their attention to special populations of readers to further broaden our understanding of how differences in cognitive capabilities influence comprehension in digital spaces. Findings from one review, for example, highlighted the nature of higher level comprehension strategy use among second-language learners as they engaged with digital texts and new technologies (Liaw & English, 2017), and another study identified important considerations among young adult readers with intellectual disabilities asked to read critically on the internet (Delgado, Ávila, Fajardo, & Salmerón, 2019). Elsewhere, Schirmer, Bailey, and Lockman (2004) outlined the processes of young deaf students as they read and comprehended different kinds of texts; Crow (2008) reported how four types of disabilities (visual, hearing, motor, or cognitive impairments) impacted students' comprehension of online reading materials; and Mann, O'Neill, and Thompson (2018) have begun to characterize differences in comprehension between deaf and hearing children as they search for and read online hypertexts.

Other studies have indicated that certain kinds of texts and tasks may enhance cognitive capabilities for readers who struggle in traditional print-reading environments. This research has included, for example, work exploring the affordances of computer-assisted instruction for students with attention deficit disorders (Raggi & Chronis, 2006), learning disabilities (Hall, Hughes, & Filbert, 2000), or intellectual disabilities (Snyder & Huber, 2019), as well as studies applying principles of Universal Design for Learning to support diverse readers with flexible learning environments and accessible content (Coyne, Pisha, Dalton, Zeph, & Smith, 2012; Dalton, Proctor, Uccelli, Mo, & Snow, 2011). Still others have focused on the collaborative use of graphic representational tools (Kiili, Coiro, & Hämäläinen, 2016) or the metacognitive scaffolding of online information search practices (Zhou & Lam, 2019) to support the cognitive

processing abilities of diverse learners in digital spaces. Findings from these studies again highlight the interplay among text, activity, and reader variables in digital spaces.

Reading and Language Competencies

In addition to variation in general cognitive capabilities, readers often vary in their knowledge of and experience with varied types of texts, which in turn influences how they move through and construct meaning from text in digital spaces. For example, individuals with varying levels of prior domain knowledge who read hypertext in less or more coherent order obtained different learning outcomes related to their construction of the textbase or of a situation model (Salmerón et al., 2005). These findings replicate what we know about the effects of reader knowledge and text coherence in linear printed texts (e.g., Goldman & Saul, 1990; McNamara & Kintsch, 1996).

Elsewhere, similar to studies of print-based comprehension performance, word-level reading skills (Bråten, Ferguson, Anmarkrud, & Strømsø, 2013; Sabatini et al., 2014) and language skills (Al-Seghayer, 2007; Coscarelli, 2018) have continued to contribute to differences in comprehension and learning as readers of varying levels of ability and linguistic competency engaged with multiple texts in varied digital reading activities. Skills in core academic language, perspective taking, and complex reasoning strongly predicted deep reading comprehension on computer-based assessments involving a variety of digital texts (e.g., blog, website, email, news article, textbook excerpt; LaRusso et al., 2016). Further, multilingual readers able to leverage the dynamic affordances of digital spaces enjoyed a broader range of opportunities to represent their comprehension of and engagement with multimodal text (Lotherington & Janson, 2011).

Other studies have highlighted how particular types of reading strategy use influences hypertext and internet text comprehension (Afflerbach & Cho, 2009; Cho & Afflerbach, 2017). Proficient readers of internet texts strategically leveraged their knowledge of topics and digital text types (e.g., search engines, websites), constructed critical questions to focus their inquiry,

and monitored both their reading pathways and their understanding of content in open online spaces (Cho & Afflerbach, 2017; Coiro & Dobler, 2007). Differences in navigational decisions and metacognitive reading strategy use also significantly predicted comprehension in digital reading spaces (Lawless & Kulikowich, 1996; Lim & Jung, 2019; OECD, 2017; Salmerón et al., 2018). Further, skilled readers of internet texts demonstrated proficiency in using a variety of source characteristics (e.g., author credentials, content, publisher, document type) to judge the quality of information (Coiro et al., 2015; Goldman et al., 2012) while applying critical evaluation processes that involved both questioning and confirming the credibility of information encountered on the internet (Kiili et al., 2019).

Reading Dispositions and Motivations

Several studies have highlighted how a reader's varied motivations, interests, and attitudes in reading print and digital texts impacted comprehension (e.g., Guthrie, Wigfield, & Perencevich, 2004; Jang & Henretti, 2019; Lim & Jung, 2019; Lupo, Jang, & McKenna, 2017). Empirical work continues to point to reader dispositions (or their attitudes, mind-sets, and beliefs) about reading, about themselves as readers, and about the nature of knowledge and knowing that influence comprehension in digital spaces. Coiro (2009), for example, found that readers who believed that the internet is useful, valuable, and engaging were willing to endure the challenges of navigating and reading across internet texts, whereas those who viewed online inquiry as a source of frustration tended to avoid using independent reading strategies and instead sought help from others (see also Coiro & Moore, 2012). Other researchers (O'Byrne & McVerry, 2009; Putman, 2014) have reported the significant role of dispositional variables, such as reflection, persistence, collaboration, anxiety, interest, and self-efficacy, and their interaction with other contextual and reader factors related to experience with technology and the internet. Similarly, differences in reader preferences (Baron, 2017) and mind-sets (Wolf, 2018) and in purposes for

reading (e.g., user-generated purposes vs. purposes generated by others; see List & Alexander, 2019; Schwan & Cress, 2017) can greatly impact one's ability to process and construct meaning from print and digital texts.

Another important area of research has explained how reader variation in epistemic beliefs significantly predicted students' evaluation of information sources, after controlling for prior knowledge and text comprehensibility (Strømsø, Bråten, & Britt, 2011). Further, Barzilai and Zohar (2012) differentiated between the complex roles of cognitive and metacognitive levels of epistemic knowledge as learners engaged in online inquiry activities while reading internet texts. Epistemic beliefs significantly impacted readers' ability to calibrate their learning to the complexity of content encountered in hierarchical hypertext (Pieschl, Stahl, & Bromme, 2008), as well as their ability to successfully engage in online research and inquiry activities, such as judging information sources, monitoring their knowing processes, and regulating their knowledge-seeking actions (Cho et al., 2017).

Sociocultural Identities

A fourth dimension of reader differences relates to the varied sociocultural identities that readers adopt in the context of specific print or digital reading environments and how these interact with other reader variables. Lee, Park, Jang, and Cho (2019) proposed a triangulation framework that integrates sociocultural, affective, and cognitive perspectives on digital literacies to better describe the multifaceted nature of youth digital literacies. This framework extends thinking to include varied social and cultural nuances in how readers see themselves and digital environments as spaces for engagement and participation. Given the important role of reader attitudes and beliefs described earlier, new identities that readers take on in different affinity spaces in both in-school and out-of-school contexts are also likely to influence comprehension as part of print and digital reading (see McCarthy & Moje, 2002).

Indeed, in *Learning and Practice: Agency and Identities*, Murphy and Hall (2008) bring together several chapters that suggest the nature of texts and activities can situate certain readers in ways that might be conducive or detrimental to their interests, depending on their self-constructed identities and perceived roles in different spaces (see also Jenkins, 2014). For over a decade, collections of studies (see Buckingham, 2007; Warburton & Hatzipanagos, 2012) have described the impact that participating in networked digital spaces had on reader identity and how readers' identity influenced their reasons for engaging with (or avoiding) particular digital texts and activities. Nash (2019) encouraged educators and students alike to consider how their own cultural beliefs, views, and practices influence the choices that they make about what to click on and how to react to diverse internet texts and perspectives as part of online reading. I propose that reading researchers should also be considering nuances of sociocultural identity as part of how to conceptualize reader variation in digital reading contexts.

Context

Finally, at least four sets of contextual elements can be useful for characterizing the broader situations in which particular readers engage with particular text types as part of particular reading activities. As depicted along the left of the outside ring of Figure 1, the first contextual element involves the medium or platform in which print or digital texts are found. This set of contextual considerations is positioned near the text element in the figure as a reminder of the context(s) in which certain kinds of texts may be found. Printed texts, for instance, may be found on a single page of paper or printed on an object such as a sticky note, index card, scroll, sign, blackboard, chart paper, or wall mural. Multiple printed pages may be shared as a loose collection of pages that can be flexibly reorganized by the reader or bound together in book

format in a particular sequence determined by the creator (e.g., magazine, brochure, paperback or hardcover book).

As readers transition into digital spaces, one or more text forms (e.g., narrative, information, multimodal, hypertext) may be located in a myriad of different digital platforms. Depending on the situation, texts can be viewed on a range of digital devices (computer, e-reader, tablet, or mobile phone), and readers may encounter multiple digital texts contained within a specific software program, mobile app, digital textbook, or online virtual world. Readers may also access texts in the context of augmented reality situations (Billinghurst & Dünser, 2012; Davis, 2015) or as part of an immersive headset-based virtual or mixed-reality experience (Amin, Arantha, & D'souza, 2018; Yang, 2019).

Each type of digital medium/platform is likely to have unique features, with the potential to hinder or support comprehension. This is especially true when these features interact with reader characteristics, such as preference or prior experience, and type of comprehension activity (e.g., accessing and evaluating digital texts vs. integrating and responding to digital texts). Indeed, researchers have begun to characterize features of different digital platforms and their relations to reading performance and reading affect. Findings illustrate both affordances and constraints of digital reading on platforms such as e-books (Larson, 2010), Universal Design for Learning e-texts (Dalton et al., 2011), e-textbooks (Dobler, 2015), collaborative digital textbooks (Kempe & Grönlund, 2019), mobile phones (Çakmak, 2019), iPads (Hutchison, Beschorner, & Schmidt-Crawford, 2012), and augmented reality applications (Bursali & Yilmaz, 2019). Efforts are now needed to summarize similarities and differences across findings from studies situated in a range of different contexts to guide the selection of digital platforms in future research and practice.

Second, when readers are asked to demonstrate their comprehension of texts while engaged in various activities, responses may take various formats, as depicted across the top of Figure 1. According to the NAGB (2017), using multiple types of response formats for demonstrating comprehension “affirms the complex nature of the reading process because it recognizes that different kinds of information can be gained from each item type. It also acknowledges the real-world skill of being able to write about what one has read” (p. 41). Thus, different item formats possess different affordances that allow evaluators access to different facets of students’ understanding.

In classroom settings, learners might be asked to write, draw, and/or orally explain what they have learned from their reading. On reading assessments, readers may encounter selected response items (e.g., multiple choice, true/false), short constructed-response items (writing on paper or typing one or two phrases or sentences in the digital interface), or extended constructed-response items (writing or typing longer, more elaborated answers of a paragraph or two) (NAGB, 2017). As large-scale reading assessments transition into digitally based assessments, a variety of new questions and task types have been introduced to capture outcome and process data, including scenario-based tasks, interactive computer tasks, and hybrid hands-on tasks (National Center for Education Statistics, 2019).

Educators have also been exploring new digital formats for students to demonstrate their comprehension, using technology to screencast think-alouds (White, 2016), record podcasts (Morgan, 2015), and digitally annotate texts that they read (Léger et al., 2019). Of course, there are ways of combining digital response formats, such as integrating digital portfolios and Flipgrid video reflection to demonstrate comprehension of complex concepts (Johnson & Skarphol, 2018), or choosing one or more of the creative response options outlined in Hobbs’s

(2017) book *Create to Learn: Introduction to Digital Literacy*. In each case, educators reported increases in student engagement and comprehension, validating the role of response type as an important indicator to consider in any study of digital reading.

A third collection of design considerations may help characterize other contextual features related to the reading activity (as depicted along the right of the outside ring in Figure 1). For example, studies involving digital reading have explored quantitative or qualitative differences related to whether the reading task was timed or untimed (Colwell, 2013); whether readers worked individually, with a partner, or in small or large groups (Hampel, 2006); whether readers read to accomplish personal or task goals (List & Alexander, 2019); and/or whether readers engaged with texts, other people, or dynamic avatars in face-to-face situations (Kiili et al., 2019), collaborative online documents (Abrams, 2019), or virtual worlds (see Coiro et al., 2019). In each of these studies, contextual design features had an impact on interaction, communication, and/or learning. Without a doubt, this set of contextual design features will continue to grow and change with new technologies that introduce new contextual affordances and constraints; in turn, many of these new features are likely to directly or indirectly influence digital reading performance.

A fourth set of contextual considerations involves features of the community in which the reading activity takes place. In her review of recent work involving students' literacies learning with digital applications or through interactions with digital devices, Hagerman (2019) argued that context and "the local situatedness of technology use" (p. 116) are central to meaning making. Further, Hagerman cited work suggesting that digital interfaces and other

placed resources (Prinsloo, 2005; Rowsell, Saudelli, Scott, & Bishop, 2013)...take on and enable the creation of meaning in relation to where they are used, when they are used, how they are used, by whom and for what situated purposes (Prinsloo & Rowsell, 2012).

Thus, this set of contextual considerations (pictured at the lower right of Figure 1) is positioned in near proximity to the reader element as a reminder that readers may take on different identities and bring diverse competencies and motivations to different communities of practice.

Although a summary of studies conceiving digital reading in these ways is beyond the scope of this commentary, at the very least, differences related to the location of a particular print or digital reading experience (e.g., at school, after-school location, at home, elsewhere in the community) are likely to interact with differences in reader factors to influence reading comprehension performance in important ways (see, e.g., Moje, Young, Readance, & Moore, 2000; Tucker-Raymond & Gravel, 2019). Hagerman's (2019) review brought to light how reading activities situated in contexts that reflect inclusivity, creativity, content knowledge learning, analytical and problem-solving skills, and interpersonal skills reflect authentic and equitable conceptualizations of digital literacy that we ought to be striving for in today's diverse world.

Where Do We Go From Here?

Overall, contemporary theories and research from national and international literacy scholars point to a wide variety of indicators that can be used to characterize comprehension in digital spaces. Unfortunately, too many studies have been dominated by definitions of digital reading that range from nonexistent to those with varying degrees of specificity. A failure to clearly define and then control for the effects of differences in texts, activities, readers, and/or contexts may explain the inconsistent results found in many studies of digital reading. Moreover, large

empirical studies focused solely on positioning print and digital reading as isolated comparable activities have done little to advance work identifying and tracking important commonalities and differences in comprehension processes and outcomes across the spectrum of print and digital spaces.

As Dillon (1992) concluded almost 30 years ago, if we are to leverage the affordances of digital texts and tools rather than just match digital reading to the features and outcomes of print reading, a broader and more realistic conceptualization of human reading is required. The multifaceted comprehension heuristic proposed in this commentary is designed to invite members of the literacy community to embrace and unpack the complexity of digital reading while also working to promote greater clarity around important dimensions of reading worthy of consideration in the future. Organizing dimensions of digital comprehension in RRSg's (2002) framework can help further expand our thinking by validating familiar understandings of text, activity, reader, and context as part of comprehension while also highlighting important differences within and across these elements as technology continues to transform our conceptions of reading in the years ahead. Researchers might, for example, refer to the heuristic to help explicate the constraints and affordances of different arrangements as different constellations of reading in this multivariate space.

Moving forward, use of the proposed heuristic of digital reading can promote a broad and complex understanding of reading comprehension that has implications for assessment, research, practice, and policy. In terms of assessment, Mislevy (2016) called for more attention to a myriad of considerations that arise when assessing performance in complex tasks. Consequently, psychometricians might select different combinations of features represented in the proposed heuristic to accurately measure the complex integration of comprehension skills and practices

required in particularized digital reading environments. In turn, recent advances in technology can be leveraged to capture and track detailed evidence of both content understanding and targeted comprehension processes in digital environments (see, e.g., Coiro et al., 2019; Kerr, Andrews, & Mislevy, 2017).

As these and other assessment instruments begin to provide psychometrically valid and reliable data, literacy researchers may also refer to this expanded heuristic to systematically explore relations between complex products and interactive performances among different kinds of readers within and across certain kinds of digital texts, activities, and contexts. Researchers might also draw from the terms in this heuristic to provide rich and explicit descriptions of the particular readers, texts, activities, and contexts most relevant in their work. Efforts to systematically name and operationalize important similarities and differences in these elements enable readers to more systematically draw conclusions across studies.

A common set of terms and definitions would also address the lack of conceptual clarity and specificity reported in most studies of digital reading (see Singer & Alexander, 2017b). In turn, conceptual clarity in studies of digital reading can pave the way for systematic comparisons and comprehensive literature reviews of how different kinds of readers perform in a range of authentic digital reading situations. In addition, complexity represented in this heuristic may inform efforts to move beyond studying digital reading in carefully controlled situations toward more design-based research methodologies that conceptualize digital reading in more flexible and contextually situated ways.

With respect to educational practice, classroom teachers, school librarians, and makerspace leaders are invited to reflect on the range of digital reading experiences apparent in their contexts and the extent to which what they observe is present or absent from the proposed

heuristic. Surely, important insights can be gained from aligning conceptions of digital reading among educators in formal and informal learning environments with those emerging among assessment designers and researchers. Formative studies that involve collaborations between educators and researchers are also likely to enhance our understanding of how to authentically assess indicators of comprehension and learning while diagnosing and supporting readers who struggle in complex digital spaces.

Finally, the proposed broadened heuristic of reading can inform literacy organizations and policymakers seeking to articulate their own values and positions about what counts as reading in a digital world. By formulating their thinking in line with important insights about digital texts, digital activities, digital readers, and digital contexts, organizations can ground their recommendations for integrating reading and technology use in research-based indicators linked to growth in comprehension, engagement, and creative response.

Perhaps most importantly, policymakers should be cautious about finalizing funding priorities and curricular decisions in the absence of conclusive findings about which kinds of students benefit most from which kinds of digital reading activities. As Baron (2017) reminded us, “digital technology is still in its relative infancy. We know it can be an incredibly useful educational tool, but we need much more research before we can draw firm conclusions about its positive and negative features” (Implications for Educators section, para. 6).

Agencies supporting efforts to improve digital reading are advised to consider elements of the proposed comprehension heuristic in their decisions about what kinds of research is needed in the years ahead. Only after we systematically embrace and unpack a more complex definition of digital reading will the literacy community be able to further advance the vigorous

and cumulative research and development program envisioned by the RRSg (2002) almost 20 years ago.

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Figure 1. A Multifaceted Heuristic To Characterize The Spectrum of Digital Reading Experiences

