Higher Order Thinking in an Online World: Toward a Theory of Web-Mediated Knowledge Synthesis

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by Michael DeSchryver — 2014

Background/Context: The rapid pace of technological change, undergirded by near ubiquitous access to the web, is producing a new learning ecology—a new ecology of information, of knowledge, of reading, of teaching, and of thinking. This instant availability of digital resources frees both time and cognitive energy that may be used to facilitate higher order thinking. This article provides a framework through which to better understand, evaluate, and scaffold the generative synthesis of knowledge in a web-mediated world.

Purpose/Objective: The purpose of this article is to describe a theory that can stimulate additional scholarly work examining higher order, or generative, thinking in web-mediated environments.

Research Design: The author outlines theory development based on two explicit steps. First, he reviews scholarly literature from educational psychology, reading comprehension, hypertext and web-based reading, cognitive flexibility, and creativity. Based on this process, he develops a proto-theory for web-based synthesis. Then, using this three-fold operationalization of synthesis, the author reports findings from a multiple-case study of advanced learners on the web, resulting in further elaboration of the concept of web-based knowledge synthesis.

Conclusions/Recommendations: The author proposes a theory of web-mediated knowledge synthesis comprising seven interacting elements: (a) divergent keyword search phrases; (b) synthesis for meaning; (c) in-the-moment insights; (d) repurposing; (e) reinforcement; (f) note-taking; and (g) creative synthesis. Through these elements, this theory provides a road map for further exploration of how web users can construct knowledge that adds value to the information they encounter every day.

Ongoing rapid technological innovation, particularly as it relates to the web, is changing how humans interact with information. Whether at school, at work, or in our personal lives, access to the web, for many users, is nearly ubiquitous. At school, 90% of undergraduates use the Internet to look for information about their studies (Selwyn, 2008), preferring the web to library resources (Griffiths & Brophy, 2005; Megnigbeto, 2006; Van Scoyoc, 2006). At work, 75% of professionals, executives, managers, and government workers use the Internet several times a day to complete job-related activities (Madden & Jones, 2008). Eighty-two percent of people use the Internet at home (Pew Internet & American Life Project, 2012), and individuals report that they use the Web to explore common problems more often than they obtain information from professionals, family members, friends, newspapers, magazines, television, or the library (Estabrook, Witt, & Rainie, 2007). For many people, searching the Internet is the first step in finding a solution to any problem (Huang, Yen, & Hung, 2012). With devices like Google Glass and smart wristwatches already in production, these trends promise only to accelerate. Integration of the web in daily life provides the foundation for a new ecology (Friday Institute, 2009; Mishra & Koehler, 2007; Spires, Oliver, & Corn, 2011)an ecology of information, of reading, of knowledge, of teaching, of learning, and of thinking that is potentially transformational (e.g., Brown, 2000; Coiro, Knobel, Lankshear, & Leu, 2008; Negroponte, 1995; Purves, 1998; Reinking, 1998; Warschauer, 2007).

At the same time, we live amidst unprecedented complexity, which increasingly requires integrated decision making and creative solutions. From nutritional choices (Gunther, 2011), to healthcare options (Thaler & Sunstein, 2008), to retirement savings decision making (Blaufus & Ortlieb, 2009), to prescription drug plan choices (Hanoch, Wood, Barnes, Liu, & Rice, 2011), individuals need to know how to harness the power of web-based content to make informed decisions in their lives. At work, fields from accounting (Friedman, 2005) to genetic engineering (Hollander, 2004) to teaching with technology (Mishra & Koehler, 2007) require creative solutions to complex, ill-structured, or wicked problems (Rittel & Webber, 1973). A number of these issues manifest on a broad scale, such as multiparty regional water issues (Adams, 2001), cyber-terrorism (Mitroff, Alpasian, & Green, 2004), and international economics (Schwab, 2011). Faced with such complexity, knowing how to find and understand information on the web is not enough. We live in an age of complexity (Schwab), for which new ways of thinking about thinking are required.

These trends have far-reaching implications. Web users can take advantage of the ubiquity of the Internet, the well directedness of search, and the ambient findability (Morville, 2005) of a seemingly unlimited scope of information to harness an unprecedented adjunct to human memory. The web has become our primary external storage system (Sparrow, Liu, & Wegner, 2011), and as people expect to have access to information anytime, anywhere, they do not feel as if they need to remember it (Huang et al., 2012). Web users can devote less time and cognitive energy to remembering the specific content in the web resources they visit. Consequently, use of the web as a primary information resource may allow for more time to engage in higher order thinking, such as creativity, analysis, and integration (J. Anderson & Rainie, 2010), steps that address the learning needs associated with complex problem solving.

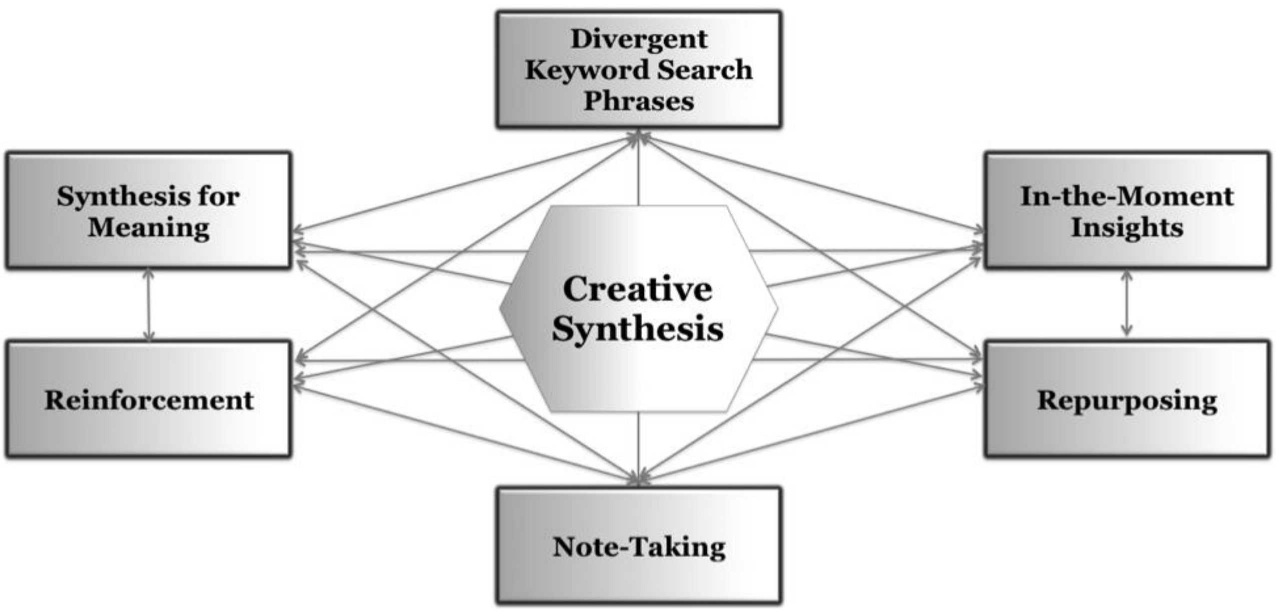
Nicholas Carr does not agree. He famously maintains that Google is making us stupid (2008) and is confining us to intellectual shallows (2010). In these concerns, he is not alone. For instance, research indicates that using the web for learning results primarily in cursory information finding (e.g., Kuiper, Volman, & Terwel, 2005). There may be several reasons for this. Maybe, as Carr argued, the web is reprogramming our brains and reducing our ability to focus. However, maybe the problem starts in our schools, where technology integration initiatives still largely result in the widespread perception that technology is merely a tool (e.g., Schrum, 2005; Thieman, 2008) or an information resource (Kuiper & Volman, 2008) to supplement the traditional learning process. For instance, Edyburn (2003) suggested that many educators have a bias for the knowledge contained in ones head over that facilitated with external devices; this indicates a preference for educational performance through naked independence. Such a bias is demonstrated in any one-to-one school where web-enabled devices are not available during assessments. Given the current focus on college and career readiness, this practice is particularly unfortunate. In the workforce, it would be counterproductive to disallow access to the Internet while solving problems; instead, ready access to knowledge banks is necessary. However, in schools, children are largely tested on what they can do when closed off from the online world, and they are rarely tested on their abilities to use the web in deep and meaningful ways. Though students will always need the foundational skills that offline learning provides, the new ecology of learning provides myriad ways for these foundational skills to work in conjunction with online and digital tools. Technology integration efforts too often view these as separate entities.

The complex nature of online reading and learning (Hartman, Morsink, & Zheng, 2010) may also explain why the web is currently used for information seeking more than for higher order thinking. Research is only recently beginning to unravel the layers of intricacy required for reading and learning on the web. For instance, exploration of the New Literacies of online reading and learning has provided a base of knowledge about web-mediated practices for children and adolescents in school and out of school that is ever growing (e.g., see Afflerbach & Cho, 2009; Castek, 2008; Coiro, 2011; Coiro & Dobler, 2007; Dwyer, 2010; Hartman, 2000; Henry, 2006; Leu, Kinzer, Coiro, & Cammack, 2004; New London Group, 1996). Much of the focus in these areas targets the skills needed to find, evaluate, integrate, understand, and communicate information online. These are all critical skills to be successful when reading and learning online, and important research focused on how to teach these skills to students is ongoing (e.g., Coiro, 2011; Hagerman et al., 2014; Zhang & Duke, 2011).

Given the technological and cultural trends noted earlier, this article argues that there is also a need for scholarly efforts to better understand the skills necessary to engage in higher order, or *generative*, thinking in web-mediated environments (e.g., Coiro, 2009; DeSchryver & Spiro, 2008; Spiro, 2006a, 2006b, 2006c, 2006d, 2006e). Knowing how to find the right information is critical. Evaluating and understanding what is found is equally important. Being able to communicate understanding through a variety of online channels is increasingly necessary. But in an age of complexity, these skills are not enough. The ability to create new knowledge, to synthesize meaning that is neither explicit nor implicit in the multitude of resources encountered on the web, will move students away from simple information consumption and toward more complex knowledge generation.

This article offers a framework for understanding and evaluating the ability to synthesize knowledge in a web-mediated environment, that is, the *theory of web-mediated knowledge synthesis*. This theory is a starting point for understanding how the web might be integrated into schools, workplaces, and everyday life in more meaningful ways. It is based on a review of scholarly literature from educational psychology, reading comprehension, hypertext and web-based reading, cognitive flexibility, and creativity, as well as empirical findings from research examining the knowledge synthesis activities of advanced learners on the web. The theory comprises seven interacting elements: (1) divergent keyword search phrases; (2) synthesis for meaning; (3) in-the-moment insights; (4) repurposing; (5) reinforcement; (6) note-taking; and (7) creative synthesis (see Figure 1). Through these elements, the theory of web-mediated knowledge synthesis provides a road map for further exploration of how web users can construct more substantive and generative knowledge that adds value to the information they encounter.

Figure 1. The theory of web-mediated knowledge synthesis



In the sections that follow, I first review the role of theory, especially as it relates to complex phenomena. Next, I discuss the literature reviews that informed theory development. Then, I describe a multiple-case study of advanced web learners that provided empirical data to theory development. Thereafter, I outline the specific elements of the theory of web-mediated knowledge synthesis, concluding with the descriptive, inferential, and applied implications of this theory for researchers and practitioners.

THE ROLE OF THEORY

Ball (1995) indicated that theory in educational research undergirds an intellectual intelligence that shifts the field away from technical rationalist approaches and promotes contingency, disidentification, and risk-taking. He wrote,

The point is that theory can separate us from the contingency that has made us what we are, the possibilities of no longer seeing, doing, or thinking what we are, do or think? (Mahon, 1992, p. 122). Theory is a vehicle for thinking otherwise; it is a platform for outrageous hypotheses and for unleashing criticism. Theory is destructive, disruptive and violent. It offers a language for challenge; modes of thought, other than those articulated for us by dominant others. It provides a language of rigour and irony rather than contingency. The purpose of such theory is to de-familiarise present practices and categories, to make them seem less self-evident and necessary, and to open up spaces for the invention of new forms of expertise. (p. 266)

The value of theory stems from its role as a conceptual system, that is, a system of concepts with relevant properties (Olson, 2003). Theories allow one to highlight relevant entities and ignore irrelevant ones (Mishra & Koehler, 2006), and, in so doing, they provide common language. Because concepts are linked logically to one another, this allows for some entities to be defined in terms of others (Olson, 2003). Theories also provide the basis for causal laws that link concepts to one another, allowing for inference, prediction, and explanation of the phenomenon. Finally, a theory based on such conceptual systems is open to elaboration and refinement over time. As such, a good theory balances the disaggregation of a complex phenomenon into its essential components, without being overly reductive, and makes the phenomenon more amenable to rigorous investigation. At the same time, the theory identifies and respects the interdependence among these components.

Another way of looking at the value of theories is to note that they succinctly describe the various essences that make up the whole of any complex phenomenon. These abstractions are important to moving our understanding forward in that they guide observation. When observing complex phenomena, simply looking, even patiently, is not sufficient. Part of seeing . . . is knowing what to look at or for, and abstractions provide a framework for what to look for (Root-Bernstein & Root-Bernstein, 1999, p. 36). In this way, theory provides the prerequisite framework for precise observation statements (Chalmers, 1976).

Mishra and Koehler (2006) suggested that educational theories need to provide information about how the concepts described can be applied in the real world. Theories of education need to help guide the design for better ways of learning, by providing the right level of analysis in order to bridge the gap between description and design (p. 29). Theories of complex educational phenomena that respect complexity can facilitate the critique of more simplistic approaches to the same phenomenon. Good educational theories can also provide a mirror that educators can hold up to their own practices to see the ways that their problems are both similar and different from those facing teachers in other settings (Bulterman-Bos, 2008, p. 413) and provide a normalizing lens to educators, broadening their scope of understanding about issues for which they have significant local (or narrowly focused) experience and understanding.

Phillips, Kennedy, and McNaught (2012) noted how scholarly inquiry in learning technology has often concerned itself with atheoretical evaluations in local learning and teaching contexts (p. 1103). They discussed the importance of robust theory for technology and learning environments, noting that such theory should be derived from empirical evidence or from other theories. The complex systems in education, and specifically those in learning technology, make it more difficult to establish broad, generalizable, and predictive theories, as does their interdisciplinary and multidisciplinary nature. As a result, theories in this area may need to be developed before they can be tested. However, this does not reduce the importance of attempting to develop a theoretical description of the phenomenon being studied, which can predict what will happen in a given context. In education, theory tries to come up with (testable) explanations of some aspect of learning (p. 1110).

This article proposes one such theorythe theory of Web-mediated knowledge synthesis. Its development path was robust. It is both grounded in well-established theories of reading and learning, and informed by empirical evidence. A diverse review of literature across five fields resulted in a proto-theory, which was then tested and elaborated on with data derived from the study of advanced learners given real-world tasks. It is imaginative (Ball, 1995), but rigorously so. It provides a common language (Olson, 2003) with which to explore rapidly emerging phenomena that otherwise have little theoretical foundation. The elements of this theory are, at times, defined by each other (Olson, 2003)demonstrating and respecting the complexity of the learning phenomenon (Mishra & Koehler, 2006). It facilitates inference (Olson, 2003) and provides predictive capability (Olson, 2003; Phillips et al., 2012). And, as is demonstrated in the next section in the transition from proto-theory to theory, it is open to elaboration and refinement over time (Olson, 2003).

FOUNDATIONS OF SYNTHESIS

The first step in theory development was a review of a diverse range of scholarly literature related to synthesis. This resulted in a proto-theory that operationalized synthesis in a way that demonstrated its complexity more than any of the individual fields reviewed. This section provides a summary of these reviews. For a more detailed accounting, see DeSchryver (2012).

Synthesis is a term used widely in a variety of teaching and learning environments. As a result, it is also a concept that has varying definitions and interpretations across scholarly fields. Several such perspectives informed the development of the framework offered in this article. Foremost among them were: (1) educational psychology; (2) reading comprehension; (3) hypertext and web-based reading; (4) cognitive flexibility; and (5) creativity. Considered collectively, ideas from these fields provided the rationale for viewing synthesis in multiple forms, not as one singular activity. In particular, a review of these fields led to the conclusion that synthesis should be broadly operationalized in two waysfirst as synthesis that supports comprehension, and second as synthesis that supports generative thinking. This important distinction is discussed in more detail next, after reviewing the individual contributions from each of these five fields.

EDUCATIONAL PSYCHOLOGY

Within the field of educational psychology, synthesis may be best known through Blooms taxonomy for the cognitive domain (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956), which has had a significant influence on educational theory and practice (Booker, 2007; Marzano & Kendall, 2007). Blooms taxonomy described synthesis as

the putting together of elements and parts so as to form a whole. This is a process of working with elements, parts, etc., and combining them in such a way as to constitute a pattern or structure not clearly there before. Generally this would involve a recombination of parts of previous experience with new material, reconstructed into a new and more or less well-integrated whole. (p. 162)

The outcome of synthesis should be unique and emphasize new meaning or structure. However, in the half-century since Blooms taxonomy first appeared, interpretations and presentations of these ideas have varied. For instance, it is common to see action verbs associated with synthesis when Blooms taxonomy is provided to educators (Almerico & Baker, 2004), some of which may conflict with the original intent when considered in isolation. For instance, some verbs associated with synthesis connote only organizational activity (e.g., arrange, categorize, compile, combine, manage, organize, rearrange, and summarize), unlike others that connote generative activity (e.g., compose, construct, create, design, develop, devise, formulate, generate, invent, and produce). Using words like *combine* and *rearrange* to describe synthesis, according to Bloom et al., should always be in the context of generative activity. In this way, Blooms taxonomy indicated that combining and rearranging were *part of the process of synthesis*, but they did not comprise synthesis when performed in isolation. Thus, Blooms taxonomy suggested that synthesis is a complex generative activity involving several skills used in concert with one another.

Any lack of clarity regarding the generative intentions of Blooms taxonomy, as well as several of its features that some considered overly simplistic (e.g., Amer, 2006; Furst, 1994; Kuhn, 2008), were addressed in a recent revision (L. Anderson & Krathwohl, 2001; Krathwohl, 2002). Among other changes, a category titled create was employed to replace synthesis. The descriptors generating, planning, and producing were used to elaborate on the notion of creating. At the same time, the revised taxonomy exchanged the positions of evaluate and create, given that

induction (involved in creation) is a more complex process than deduction. Deduction involves breaking a whole into subparts, evaluating them, and determining whether criteria are met. Induction, on the other hand, involves finding things that could fit together, judging their appropriateness, and assembling them to best meet criteria. (L. Anderson & Krathwohl, 2001, p. 310)

Consequently, generative activity was established as the highest order thinking skill in the revised taxonomy.

The most current manifestation of these ideas is Blooms digital taxonomy (Churches, 2008), in which there exists a new set of digital verbs attached to the cognitive processing dimensions of the revised taxonomy. For example, at the lowest levels, the concept of remembering is evidenced by Googling, whereas blogging and twittering are associated with understanding. As outlined by Churches, all these verbs represent inherently web-based activities, directly relating Blooms ideas to the new ecology of learning. At the same time, given that the underlying structure of Blooms revised taxonomy remains unchanged in this digital version, generative activity is still considered to be the highest order thinking skill.

READING COMPREHENSION RESEARCH

Within the field of reading comprehension research, three specific areas provided information relevant to synthesis: (1) inferencing, (2) summarizing, and (3) multiple text comprehension.

Inferencing

Making inferences about text content is one of the nine basic reading skills (Davis, 1944) and is at the heart of the comprehension process (Dole, Duffy, Roehler, & Pearson, 1991). It is a higher order activity (Cho, 2011; Graesser & Kreuz, 1993; Graesser, Millis, & Zwaan, 1997) based on the interactions among the text and the previous knowledge of the reader. Inferencing fills in details that are not explicitly stated in the text and allows the reader to elaborate on what is read (Dole et al., 1991). W. Kintsch (1998) indicated that some inferences come from simple retrieval, whereas others result from active memory processes generating new information (Rouet, 2006). Automatic retrieval inferences result from topic-specific associations between information in working memory and prior knowledge. Controlled retrieval inferences require a more conscious and extended search of memory for specific links based on cues in short-term memory. Automatic generative inferences result from general world knowledge about the evolving mental representation of source material. Additionally, controlled generative inferences occur when deductive reasoning and logic help to fill in gaps in the text, which relies heavily on prior knowledge (W. Kintsch, 1998; Rouet, 2006). Together, these devices allow readers to properly understand a text (W. Kintsch, 1998, p. 189), resulting in coherence at both local and global levels.

Summarizing

The ability to summarize text is also important to successful reading comprehension (Dole et al., 1991). Good readers sift through large units of text, differentiate important from unimportant ideas, and then synthesize those ideas and create a new coherent text that stands for, by substantive criteria, the original (p. 244). Hidi and Anderson (1986) described the process of text summarization in great detail, which includes comprehension, evaluation, condensation, and transformation of ideas in the original text. During summarization, some sections of the text are deleted, while others are purposefully included in the summary. Condensation occurs by substituting higher level, more general concepts for lower level concepts with more detail. Finally, integration, combination, and transformation of text occur to provide the most accurate representation of the original text. According to Hidi and Anderson, the major concerns of the summary writer, therefore, are not how to plan and generate new content (p. 472, emphasis added), but how to understand and encapsulate meaning that already exists within the text.

Multiple Text Comprehension

The comprehension of multiple texts is a complex task based on comparing, contrasting, relating, and differentiating information across various texts (Afflerbach & Cho, 2009; Perfetti, Rouet, & Britt, 1999; Rouet, 2006; Wineburg, 1991). This can involve building intertextual links (Afflerbach & VanSledright, 2001; Hartman, 1995; Stromso, Braten, & Samuelstuen, 2003; Wolfe & Goldman, 2005) and requires constant revision of ones own understanding of and reaction to previous text (Hartman, 2000). Cho (2011) described this process succinctly:

Readers learn the content conveyed across different texts, relating the currently read text to previous texts, cross-referencing and extracting related information, assembling different ideas into globally coherent meaning, and continuously elaborating a cross-textual mental modelsynthesis strategies are highly required in the construction of cross-textual meaning. (p. 64, emphasis added)

Unlike single text comprehension, multiple documents may complement each other and may also fill in the gaps of other documents by confirming or disconfirming inferences the reader may have made about them. Because each document typically only contributes to the overall understanding of the topic or situation, the reader is responsible for recognizing global relationships that can be integrated into a coherent whole.

Many of the same terms used to describe Blooms conception of synthesis are similarly used to describe these three reading comprehension strategies. In fact, Dole et al. (1991) and Cho (2011) identified summarizing and multiple text comprehension, respectively, as dependent on the ability to synthesize. However, across all three strategies, there is one significant difference when compared to Blooms Taxonomy. In each case, the outcome of synthesis activity in reading research is more complete understanding of the meaning of the text encountered and not, as Bloom et al. (1956) explicitly asserted, the generation of new knowledge.

HYPERTEXT AND WEB-BASED READING RESEARCH

Building directly on the reading comprehension research, the fields of hypertext and web-based reading provided the foundation for considering synthesis in digital, nonlinear, online reading environments. Landow (2005) described hypertext as an information medium that links verbal and non-verbal information . . . thereby creat[ing] text that is experienced as non-linear, or more properly, as multilinear or multisequential (p. 3). This information includes text, video, sounds, animations, images, maps, and diagrams, and there is not a specific beginning or end point. Bolter (1998) indicated that the primary feature of hypertext is its fluidity; each hypertext experience is a set of different potential texts awaiting realization (p. 5), which leads to an unstable and unpredictable environment. Similar to offline text, the readers experience with hypertext is primarily one of meaning construction (Bolter, 1998). However, whereas offline meaning construction is primarily invisible and internal, hypertext reading demonstrates more external manifestations of meaning making through the choices of links followed. Because of the increased complexity provided by the hyperlinking structure, certain skills identified for successful offline comprehension may be even more important when reading hypertext. For instance, abstract link labels and incoherent transitions (Coiro, 2007, p. 34) require increased use of inferential reasoning (Wenger & Payne, 1996). Based on such inferencing, Kim and Kamil (1999) demonstrated how successful hypertext readers were able to make effective predictions about what information specific links might provide. At the same time, the increased multiplicity of resources increases the demands for cross-textual linking, and the related synthesis strategies thereof.

When considering the extension and elaboration of these ideas to the web, the *new literacies of online reading comprehension* (e.g., see Coiro & Dobler, 2007; Leu, Reinking, et al., 2007) and *constructively responsive reading on the Internet* (Afflerbach & Cho, 2009) are frameworks that explore how synthesis activities manifest online. The former offered a *taxonomy of Internet comprehension skills and strategies* (TICA) (Taxonomy, n.d.) that specifically identified synthesis as a primary component. Therein, synthesis is defined by gathering information from multiple media sources, sorting relevant from irrelevant information, and organizing it effectively through the use of note-taking and adjunct tools (Taxonomy, n.d.). These skills help readers to actively construct the text that they read through the choices they make about which sites to visit and assemble an understanding of what they have read (Leu, Zawilinski, et al., 2007, p. 48). Though not explicitly stated as synthesis, Afflerbach and Cho (2009) similarly described one of the key Internet reading strategies as combining disparate forms of information from multiple websites and resources to construct meaning. In this way, both frameworks identify synthesizing activity for which the result is meaning making.

COGNITIVE FLEXIBILITY

Cognitive flexibility theory (CFT) (Spiro, Feltovich, Jacobson, & Coulson, 1992) and cognitive flexibility theory on the web (CFT-W) (Spiro & DeSchryver, 2010) both provide additional insights about synthesis. CFT is a constructivist, or generative, theory for which each application of knowledge in use is unique. It devalues storage or fixed knowledge and instead promotes the mobilization of potential knowledge (p. 649). This is accomplished through the flexible use of preexisting knowledge and through the acquisition of new knowledge in ways amenable to flexible application (Spiro et al., 1992). This flexible use of prior knowledge is not based on the recall of intact schematic representations, but the reassembly of multiple pieces of prior knowledge into a new schema-of-the-moment.

CFT-W is a revisitation and extension of CFT for the open hypertext-learning environment afforded by the web (Spiro & DeSchryver, 2010). Several enabling affordances of the web were identified through CFT-W that support its fundamental cognitive and metacognitive processes. Among these is the cognitive process of virtual conceptual simultaneity. This occurs when many ideas are simultaneously considered in the context of each other, across multiple resources, and from which conceptual wholes greater than the sum of the parts can form (Spiro, 2006e, p. 2). Based on the enabling affordances of speed, scope, and nonlinear random access on the web and the associative cognitive process of spreading activation, ideas encountered by the learner from multiple sources appear simultaneously in functioning cognitive space. Experiencing the often-heterogeneous resources in this way may lead to the recognition of loose interconnections among them (i.e., connections that might otherwise not appear to the reader), including those not implied in the texts. In this way, virtual conceptual simultaneity supports generative forms of synthesis.

CREATIVITY

In the research literature, discussions of creativity and synthesis are often overlapping. Bloom et al. (1956) noted that synthesis is the category in the cognitive domain which most clearly provides for creative behavior on the part of the learner (p. 162). As previously noted, synthesis in Blooms taxonomy became creating in Blooms revised taxonomy (L. Anderson & Krathwohl, 2001; Krathwohl, 2002). Synthesis is also the term that has been used widely to describe components of the creative process (e.g., Osborn, 1953; Ward, Smith, & Finke, 1999) or the extent to which something is creative (Besemer & OQuin, 1989). Given this overlap between synthesis and creativity, the following characteristics of creativity emerged as relevant to exploring synthesis. First, creativity is considered in the context of a problem space (e.g., Amabile, 1983; Osborn, 1953; Wallas, 1926), resulting in generation of a perceptible product as a solution to a given task (Plucker, Beghetto, & Dow, 2004). Second, creativity relies on incubation. Letting up, or mental resting, allows for active unconscious work, spreading activation, or associative play on the problem at hand (e.g., Finke, Ward, & Smith, 1992; Lubart, 1999; Osborn, 1953; Segal, 2004; Smith, 1995). One of the key features noted about incubation is the temporal consideration; that is, incubation requires time. Third, creativity involves a process of iteration (Bruner, 1962; Csikszentmihalyi, 1997; Sternberg & Lubart, 1999; Ward et al., 1999). Finally, for something to be considered creative, it must be demonstrated to be organic, well crafted, and elegant (e.g., Besemer & OQuin, 1989)or whole (e.g., Mishra & Koehler, 2007). This characterizes many of the somewhat intangible qualities of products to which creativity leads.

Considering these elements of creativity in the context of synthesis, it is apparent that sometimes synthesis is creative, and sometimes it is not. For tasks or problems where enough time is allowed for incubation, the process is iterative, and whole solutions may emerge, synthesis can be creativebut sometimes synthesis demonstrates none of these characteristics.

Creativity literature also demonstrated the evolution of an organic relationship between technology use and creativity. That is, technology use often requires creativity and technology may enhance creativity (DeSchryver & Mishra, 2008). This relationship is based on the overlapping affordances of technology and the underlying processes of creativity. For example, the creative cognition approach provides details about how the generation, exploration, and integration of ideas manifest (Ward et al., 1999). This occurs through a retrieval of existing ideas from memory, followed by associating or combining those ideas to form new, well-integrated concepts. It also incorporates analogical transfer of ideas from one domain to another and categorical reduction of ideas. During the exploratory phase, creative cognition involves searching for the novel and desirable attributes, metaphorical implications, or functionality of ideas. Though originally proposed in the context of offline thinking, these processes are accommodated and arguably enhanced by the affordances of keyword searching on the web. As viewed through the lens of technology, the creativity literature offered similar insights to the steps involved in technology-supported synthesis activities.

(RE)DEFINING SYNTHESIS

Insights collected across the five fields of literature reviewed earlier in this article provided the base from which to view synthesis as a more complex activity than any single field of research provided. That is, synthesis was broadly operationalized in two waysfirst as *synthesis for meaning* and second as *generative synthesis*.

Synthesis for Meaning

Synthesis for meaning describes activities primarily associated with developing understanding of explicit and implicit meanings of the text encountered. It occurs when learners organize, combine, compose, rearrange, rewrite, compile, and structure information in a way that facilitates their understanding of the multiple texts they approach (Dole et al., 1991; Duke & Pearson, 2002; Glister, 2000; Hartman, 1995; Leu, Zawilinski, et al., 2007; Rouet, 2006; Stromso & Braten, 2002). Key components of synthesis for meaning involve sorting relevant from irrelevant information and organizing it effectively (Taxonomy, n.d.), summarizing information (Dole et al., 1991; Hidi & Anderson, 1986), making inferences about the authors implied meaning or intent (Dole et al., 1991; W. Kintsch, 1998; Scharer, Pinnell, Lyons, & Fountas, 2005), and relating the text to background knowledge (Dole et al., 1991). On the web, the texts to be synthesized are available in multiple media formats (e.g., written text, audio, images, video, table, graphs); thus, online readers must be proficient at summarizing information from multiple sources as well as multiple types of sources.

Generative Synthesis

Generative synthesis describes activities whereby learners generate knowledge that is neither explicitly stated nor implied in the text they have viewed. Two different forms of generative synthesis are proposed.

Isolated generative synthesis. This first form of generative synthesis often happens in-the-moment, in that there is not a substantive delay in time between viewing the text and the related knowledge generation. The knowledge generated may contribute to whole solutions but does not constitute a whole solution on its own. It is often task agnostic, where the ideas that emerge are related to the resource(s) recently visited more so than the primary learning task. On the web, synthesis of this type may be supported by the cognitive affordance of the virtual conceptual simultaneity (VCS) of resources. Based on this, multiple, heterogeneous ideas or resources are simultaneously being considered in the context of each other from which conceptual wholes greater than the sum of the parts can form (Spiro, 2006e, p. 2). It may be more prevalent on the web than with offline resources because the online reader can rapidly click from one resource or idea to another. Ideas accessed from multiple sources may be subject to simultaneous processing within the same functioning cognitive space, and this can lead to conceptual breakthroughs. Given its generative nature, isolated generative synthesis may rely on the various processes that undergird creativity, but typically not to the extent that creative generative synthesis does.

Creative generative synthesis. This second form of generative synthesis occurs over longer periods of time, allowing for incubation and iteration, processes theorized to undergird creativity (Bruner, 1962; Csikszentmihalyi, 1997; Osborn, 1953; Sternberg & Lubart, 1999; Ward et al., 1999). Knowledge generated through this process serves as new and more or less well-integrated whole (Bloom et al., 1956) solution to a given task. Given the longer periods of time often associated with creative generative synthesis, the results of this form of synthesis are typically task specific, or related to the primary task or purpose more so than the resources just recently viewed. Creative generative synthesis is a composite of the other forms of synthesis working in concert toward a solution. As such, creative generative synthesis may comprise multiple instances of synthesis for meaning and/or isolated generative synthesis.

These conclusions provided a detailed proto-theory of synthesis from which to further examine the phenomenon of web-mediated synthesis in an empirical study.

EMPIRICAL EXPLORATION OF SYNTHESIS ON THE WEB

The next step in theory development was to conduct an empirical exploration of this proto-theory in a web-mediated learning environment (DeSchryver, 2012). The goals for this study were twofold. First, the study was designed to test whether the three forms of synthesis outlined in the proto-theory existed in a web-mediated learning environment and, if so, provide detailed illustrations of how they manifested. Second, the study was also designed to capture and illustrate any emergent forms of synthesis activity in a web-mediated learning environment not accounted for in the proto-theory. A brief summary of this study is provided next. See DeSchryver (2012) for a detailed accounting.

This study used purposive sampling (Patton, 1990) to identify eight sophisticated web users from a pool of doctoral and law students. For example, all participants self-reported that they used the web extensively for learning and demonstrated the ability to construct relevant search phrases, utilize advanced Google search features, properly evaluate web resources, and employ strategies for using more than one web page at a time. Each participant spent 2.5 hours in a research session. They were asked to use the web to complete the following two tasks:

Reading-to-Learn Task: Please use the next hour to learn about why some people make decisions to change their behavior in ways that may lessen the effects of climate change and why some people do not choose to change their behavior in ways that may lessen the effects of climate change. Please use the learning time you have to prepare as if you are going to be part of a public panel on this topic that will represent a diversity of perspectives.

Reading-to-Do Task: After such a good showing in the public panel about individual choices related to climate change, you have been hired by an environmental non-profit. Your first day on the job, the director of the nonprofit asks you to come up with some new, creative ideas about how persuade three specific groups of people to voluntarily change their behavior in ways that will help lessen the effects of climate change: (1) college students; (2) high-SES professionals; and (3) individuals with strong religious affiliations. The director would like to hear any thoughts you have about targeting these three groups at the afternoon staff meeting 45 minutes from now. Though the director was clear that your ideas should be new and creative, he also indicated that they should be backed up with some evidence of their potential to be successful strategies.

When completing these tasks, participants used a web browser, narrated their thinking process, took notes, and used their own online and offline techniques for saving and organizing information. Data sources included (a) audio recordings of participant think-alouds, (b) retrospective interviews, (c) clickstream, (d) screen video capture, and (e) task-specific artifacts (e.g., notes taken during the tasks).

DATA ANALYSIS

Analysis of these data utilized abductive coding techniques (Morgan, 2007). Coding began deductively, and then new coding processes occurred based on information that emerged from the data. The first coding pass on the data focused entirely on synthesis moments, using codes for (1) synthesis for meaning, (2) isolated generative synthesis, and (3) creative generative synthesis. In approaching the data, the notion of propositional clusters (van dijk & Kintsch, 1983) provided the initial parsing lens. According to this construct, the unit of analysis comprises a cluster of propositions focused on the same idea (Coiro & Dobler, 2007, p. 227). This was adapted to identify the data in synthesis clusters comprising propositions that represented an instance of one element of synthesis.

During this first coding pass, several instances of synthesis emerged that were not explained by the preliminary coding system. Consequently, I employed the constant comparative process (Bogdan & Biklen, 2003; Dye, Schatz, Rosenberg, & Coleman, 2000; Merriam, 1988) as an iterative process to modify existing codes and generate and apply new codes. Once a new set of codes was identified, two experts in the field of online reading and learning validated and critiqued them. These experts viewed multiple samples of each synthesis element. As was the case with Hartman (1995), the primary purpose of this exercise was to confirm or disconfirm the perceptions, hypotheses, and interpretations made during the construction of these elements. There was 100% agreement regarding the existence of the elements presented to these experts, and the definitions were modified for precision based on their feedback. As a result, seven elements of web-mediated synthesis were established: (1) divergent keyword search phrases; (2) synthesis for meaning; (3) in-the-moment insights; (4) repurposing; (5) reinforcement; (6) note-taking; and (7) creative synthesis. DeSchryver (2012) described the evolution of these elements in more detail.

Data were then coded one final time based on these new categories, and expert raters reviewed several examples of their application. The interrater agreement for these examples was initially 50%. After discussion, agreement was achieved for 90% of the examples. This discussion not only resulted in a high level of expert agreement but also explored the nuances of categorizing the synthesis moments provided, given their complexity (i.e., a synthesis moment could include several minutes of web searching and think-aloud data from multiple resources, at multiple points in time). The experts also concluded that even with well-operationalized elements, many ambiguities exist when applying codes to a concept as indeterminate and irregular as synthesis. This is consistent with Barbours (2001) assertion that in qualitative research, the degree of agreement is less important than the content of disagreements and insights that discussion can provide. These discussions also suggested that for the 10% of synthesis instances for which agreement was not met, the examples could be accurately coded several ways or with multiple codes.

Based on the results of the mentioned analyses, three additional analyses of the think-aloud and screen capture video were performed. First, every keyword search phrase was coded as either consistent or divergent, based on whether any words used by subjects in the search phrases were not included in the task prompts provided to the participants. Second, data from audio recordings of participants talking about their background knowledge about climate change and their interviews were used to corroborate (triangulate) and extend ideas that emerged from the mentioned analysis. Finally, each instance of synthesis from in-depth case studies of two participants was examined to identify what role note-taking played in their synthesis activities.

RESULTS

The primary findings of this study corroborated some elements of the proto-theory, altered and elaborated on others, and provided new elements for consideration. After analysis, seven skills emerged. Each element is defined explicitly next, along with data reporting the incidence of use.

Divergent Keyword Search Phrases

The use of keyword search phrases is one of the primary reading strategies that differentiates web-based reading from its offline and hypertext ancestors (Afflerbach & Cho, 2009; Guinee, Eagleton, & Hall, 2003; Kuiper, Volman, & Terwel, 2009; Leu et al., 2009). The data in this study confirmed this literature. The eight participants conducted 158 keyword search phrases and utilized 242 unique keywords. Of even greater interest was the extensive use of divergent keyword search phrases, or words and phrases *not* provided in the task, to guide searching and ongoing knowledge construction. Of the phrases used, 122 were divergent and 36 consistent.

Synthesis for Meaning

Most prior conceptions of synthesis in reading comprehension, multiple text comprehension, and web-based reading focused on how readers organize, combine, compose, rearrange, rewrite, compile, and structure text when synthesizing information (Dole et al., 1991; Duke & Pearson, 2002; Glister, 2000; Hartman, 1995; Leu, Zawilinski, et al., 2007; Rouet, 2006; Stromso & Braten, 2002). The explicit goal of these activities is to make meaning and understand the text being read. The data in this study confirmed extensive use of this process to make meaning of the web text encountered, with 113 instances of synthesis for meaning across the participants.

In-the-Moment Insights

In the proto-theory of synthesis, isolated generative synthesis broadly described a process that the data in this study demonstrated to be complex enough to warrant several categories. The first category emerged as in-the-moment insights. That is, the participants in this study frequently demonstrated insights based either on (1) a single web resource; (2) multiple web resources (supported by the concept of virtual conceptual simultaneity; Spiro, 2006e); (3) activity unconnected to the web (e.g., insights based on background knowledge or idea-play); or (4) a combination of the prior three possibilities. The process of selective combination (Sternberg, 1988), whereby the reader combines what might originally seem to be isolated pieces of information into a unified whole that may or may not resemble its parts (p. 136), may undergird these insights. The data demonstrated 68 instances of in-the-moment insights across the participants.

Repurposing

The second category of isolated generative synthesis emerged as a form of repurposing. To illustrate, the participants recast, reused, or otherwise tweaked ideas they encountered in text to fit a new context. These instances demonstrated generative experiences because they added value to the ideas that originated in the texts. They actively transformed a singular idea much in the way that Kress (2000) described how transformation, remaking, editing, and juxtaposition of texts create new and alternative meanings. In these cases, the relationship between the original and repurposed ideas was one-to-one, with a parallelism of meaning remaining intact from the first occurrence to the repurposing. The data demonstrated 41 instances of repurposing across the participants.

Reinforcement

The third category of isolated generative synthesis emerged as a form of reinforcement. That is, when the participants encountered ideas that they had previously synthesized, a reinforcement of those ideas occurred, often from a different perspective or in a different context. Given the scope of resources available on the web and speed of access to them, the potential for such interactions is much greater than in offline texts or hypertext systems. In the data from this study, these experiences provided confirmation to the readers regarding their own ideas and interpretations, and were often associated with increased affect. It is important to note that these interactions were not revisitations of the same text-based information, as outlined in CFT (e.g., Spiro, Coulson, Feltovich, & Anderson, 1988), nor were they occurrences of the same idea in different resources, as accommodated by CFT-W (Spiro & DeSchryver, 2010). They were new instances of synthesized knowledge, such as that provided by in-the-moment insights or repurposing. In some cases, the reinforcement of those ideas led to even further elaboration with even more generative ideas. The data demonstrated 29 instances of reinforcement across the participants.

Note-taking

Seven of the eight participants took extensive notes, at least two pages and as many as five. One participant took only about 1/4 of a page of notes. Three participants used all offline notes, two used Microsoft Word and some offline notes, one used only Google Docs, and one started offline and finished in Microsoft Word. Six of these seven participants began separate notes for the reading-to-do task.

The notes varied from verbatim to summary. All notes taken on the computer were linear in nature and often involved bullet points, lists, or outline formats. The offline notes were primarily linear, but nonlinear affordances were used (e.g., arrows, circles, brackets, sectioning). Additional mark-ups identified important elements (e.g., asterisks, stars, underlining). More important, nearly all the synthesis elements demonstrated in this study resulted in, or from, note-taking.

Creative Synthesis

The data confirmed the existence of a task/problem-based creative synthesis as outlined in the proto-theory. It presented as a variety of combinations of the other forms of synthesis, especially in the reading-to-do tasks. It was iterative, including text from the web, background knowledge, and idea-play as part of the process. Across all eight participants, the reading-to-do tasks included at least one extended interaction that demonstrated creative synthesis. Note-taking was particularly supportive of creative syntheses. In several cases, the participants started the process of creative synthesis by brainstorming in their notes without accessing the web, and then they used the web to explore, confirm, and elaborate on those ideas. Many participants also discovered new ideas through further exploration on the web and added them to the evolving creative synthesis.

LIMITATIONS

When using the findings from this study to help develop the theory of web-mediated knowledge synthesis, two primary limitations are relevant. First, though the *use of think-alouds* is common for reading and web-based research, it provides only a small window into the inner workings of the mind . . . limited by the awareness of [participants] of their own thought processes and their ability and willingness to communicate this awareness (Hartman, 1995, p. 530). The participants in this study were advanced learners who may have had a higher awareness than most in this area, however, the limitations of the think-aloud process still existed. Second, *topical limitations* were inherent in this study. That is, if a topic was more relevant to one participant than another, his or her motivation and ability to engage in synthesis may have been enhanced or diminished. However, because this study endeavored to explore and explicate synthesis, the fact that one participant may have synthesized more than another would not have impacted the broader goals of theory development.

THEORY OF WEB-MEDIATED KNOWLEDGE SYNTHESIS

Based on a thorough review of the literature, this article reconceptualized synthesis to include synthesis for meaning and two forms of generative synthesis. This article also used the results from a study of advanced learners to demonstrate how synthesis for meaning and several additional forms of generative synthesis emerged in reading-to-learn and reading-to-do tasks about an ill-structured topic in a web-mediated environment. Together, these contributions provide a new lens with which to view reading and learning on the web. That is, they provide the foundation for a theory of web-mediated knowledge synthesis. Next, this theory is explained through a detailed discussion of the seven interacting elements that emerged from its development process.

DIVERGENT KEYWORD SEARCH PHRASES

Henry (2006) noted that all other decisions and reading functions on the Internet emanate from the decisions that are made during the search process (p. 616). The theory of web-mediated knowledge synthesis proposes that among those decisions, the extensive use of divergent keyword search phrases is particularly important for synthesis on the web. There are two arguments for this.

First, across all eight participants in DeSchryver (2012), the use of divergent keyword search phrases outnumbered consistent search phrases more than 3 to 1. That is, the advanced learners in this study demonstrated activity consistent with what White and Drucker (2007) called explorersweb users whose search paths, guided by divergent keyword phrases, branched frequently, included many different keyword queries, and visited new domains of information. Though keywords can be divergent within a narrow scope of domains (e.g., the sequential iteration of search phrases based only on synonyms for the same word[s]), the data from this study also indicated that divergence of keywords across domains might support synthesis to an even greater extent. Finally, in this study, divergence was partially achieved through the use of multiple keywords per search phrase. Unlike the participants in Nachmias and Gilads (2002) study of search behavior, in which the use of single keywords was the most common search strategy, the two in-depth case study participants in this study averaged 5.9 and 4.8 keywords per search phrase, respectively.

Second, the selection of divergent words for inclusion in a search phrase may itself be a form of generative synthesis. That is, the choices of divergent words to include in any given phrase may represent an active integration of entirely new categories, subjects, or fields of information by the learner. For example, when one participant in DeSchryver (2012) decided to use the divergent search phrase [religious views on climate change] in her reading-to-learn task, she said So, when I just read about the science, part of this topic [in the task instructions] says to open up to others, I wonder if any . . . if religion affects your view on climate change. When interviewed, she elaborated on how this phrase developed in her mind:

I was reading about the government citing all these scientific articles, and in my mind when I think scientific articles, we try to search for the truth. . . Im not a particularly religious person, but in religion they try to do the same thing through different means. So I was like, that can give me perspective, people tend to follow their religion, people tend to do their behaviors, based on their religion. Think about how the government can cite all of these articles, but if people arent listening to the science, and listening to something, and something else that can be viewed kind of opposite, or kind of go against science would be religion, so I wanted to get the opinions of that.

Her decision to choose that particular keyword search phrase was based on her synthesis of meaning across the Web text, task instructions, and in-the-moment insights based on her background knowledge. This is also consistent with White and Druckers (2007) conception of the web explorer as one who is cognitively complex, applies a global approach to learning, and focuses on the relationships between multiple ideas during the learning process.

SYNTHESIS FOR MEANING

Synthesis for meaning, both within a single web resource and across multiple sites visited, is a critical element in the overall consideration of web-mediated synthesis. In the proto-theory, synthesis for meaning included a variety of activities. In DeSchryver (2012), it was the most common form of synthesis across the eight participants. Several instances of synthesis for meaning resulted from common reading comprehension strategies such as summary, inference, and relating to prior knowledge (Dole et al., 1991; Hidi & Anderson, 1986; W. Kintsch, 1998; Scharer et al., 2005). When synthesizing for meaning, the participants were, by the very act, sorting relevant web information from the irrelevant (Taxonomy, n.d.), and the participants notes that resulted from synthesis for meaning during their tasks represented the active construction of their own personal text (Leu, Zawilinski, et al., 2007).

Knowledge that is synthesized for meaning also contributes to the other forms of generative synthesis outlined in the theory of web-mediated knowledge synthesis. In DeSchryver (2012), synthesis for meaning was at various times (1) a direct antecedent to generative synthesis; (2) later repurposed in a generative way; (3) the content and context for combinatorial idea-play leading to insight; or (4) integrated directly with generative syntheses to comprise a creative synthesis. This relationship between synthesis for meaning and generative synthesis is supported in previous literature. That is, generative syntheses, such as insight and repurposing discussed next, may rely on domain knowledge (e.g., see Csikszentmihalyi, 1997; Lubart & Sternberg, 1995). In the absence of significant prior knowledge in a domain, synthesizing meaning in the moment may serve to fill in gaps in this domain knowledge, which then facilitates generative synthesis. Sternberg (1988) summed up how important synthesizing meaning may be in the absence of domain knowledge when he said, It is impossible to have novel ideas about something if one knows nothing about it (p. 137). As such, synthesis for meaning may be foundational to generative syntheses.

IN-THE-MOMENT INSIGHTS

In-the-moment insights describe a form of isolated generative synthesis that provides value-added knowledge neither explicit nor implied in the text encountered. The data in DeSchryver (2012) demonstrated the complexity of insight behavior by the fact that it occurred under the most varied and unpredictable conditions of any synthesis element. Insights emerged based on bulleted lists of text in a single article; after successive review of as many as 18 different topics across several articles; when skimming text; when reading text at a deeper level; by combining new information with background knowledge; and based on idea-play. Insights also manifested following review of both soft and hard resources, as a result of one-to-one relationships (i.e., one idea in the text facilitated an insight), and as a result of many-to-one relationships (i.e., several ideas in the text considered in virtual conceptual simultaneity lead to a single insight). Insights resulted during both reading-to-learn and reading-to-do tasks. They also appeared in concert with other forms of synthesis. They occurred in the midst of several syntheses for meaning, were at other times reinforced themselves by background knowledge or Web text, and comprised large portions of the creative syntheses documented.

Web-mediated insight is a relatively unpredictable phenomenon, with the exception of two common themes. First, in DeSchryver (2012), insight often occurred when learners were concerned with ideas, and not when they were focused on remembering or documenting the meaning of what they were reading. This is supported by theories of creativity that emphasize the importance of piling up alternatives (Osborn, 1953) and associating or combining those ideas (Ward et al., 1999) when thinking generatively. In this way, the mindset of the reader may be most important to promoting insights. Second, such focus on ideas often leads participants to skim and skip around the text (including their own notes). Given the emphasis on incubation in creativity literature (e.g., Wallas, 1926), the cognitive pauses when skimming and skipping around may provide just enough time for subconscious combination and recombination of ideas to promote insight.

Finally, it is important to differentiate how insight is conceived in this theory from its common use in psychological and creativity literature. As used here, insight is not a solution as it is often described when insight is studied in the context of insight problems (e.g., Weisberg, 1985; Weisberg & Alba, 1981). In this theory, it is described as any idea or knowledge that emerges as a value-added to the text that was neither explicit nor implied in the text. It does not have to be a light bulb moment that happens suddenly and unexpectedly, as is otherwise commonly associated with insight. In this way, the insight described in this theory should be considered little-i or everyday insight, just as creativity itself has been differentiated as little-c and big-C creativity (e.g., Beghetto & Kaufman, 2007; Sawyer, 2012).

REPURPOSING

While in-the-moment insights essentially provide new information to the web user, the act of repurposing allows him or her to modify existing ideas in substantive and generative ways. A repurposed idea retains one or more of the important qualities of the original idea while changing or adding other qualities. In DeSchryver (2012), ideas were repurposed in several ways during both reading-to-learn and reading-to-do tasks: from one context to another; by using ideas in the opposite way they were presented in the text; by reorienting ideas to a different scale than that explicit or implied in the text; by repurposing ideas in two different ways; and by combining repurposed ideas with insights. Ideas from both soft and hard resources were repurposed, and repurposing occurred in both task-relevant resources and those that were more far afield. However, resources that were very close in content area to the task may have been less amenable to repurposing.

The roots of repurposing can be found in learning, creativity, and design scholarship. The notion of transfer in learning is a broad concept that explores how learners apply or generalize what they have learned in similar or dissimilar contexts (Barnett & Ceci, 2002). It is best considered across nine different dimensionslearned skill, performance change, memory demands, knowledge domain, physical context, temporal context, functional context, social context, and modalityand applies equally to skills and knowledge. Given the emphasis of repurposing on ideas, it is similar to transfer within the knowledge domain. However, the difference between transfer among knowledge domains and repurposing in the context of this theory is that transfer is typically the application of already learned knowledge, whereas repurposing is a component of the learning process. A repurposed idea is integrated into an ongoing knowledge construction, whereas transfer often takes the results of constructed knowledge and applies it wholesale or with minimal adaptation.

Though these differences exist, both the conditions and the mechanisms of transfer can inform how repurposing manifests. In particular, the idea of abstraction is helpful to understanding how readers may repurpose ideas. Transfer may depend on both the level of abstraction of the phenomenon to be transferred (i.e., highly abstract ideas may be more transferrable), and whether learners have actually abstracted the critical attributes of that phenomenon (Perkins & Salomon, 1994). Given that any situation, process, skill, or idea can have multiple abstractions (or essences) that together explain it fully (Root-Bernstein & Root-Bernstein, 1999), the more abstractions that exist for a given phenomenon, and the extent to which the learner understands all these essences, will impact how well transfer is accomplished. Consequently, transferred knowledge is typically not considered generative because its essences remain intact during application. By contrast, a repurposed idea often keeps intact one or more of the abstractions while changing one or more others to comprise the generative and value-added components.

Creativity literature provides further explanation of repurposing through the lenses of adaptation and reuse. For instance, Hofstadter (1985) described creativity as variations on a theme. The common tests for creative ability use divergent thinking tasks, which are often a measure of the ability to list the different ways to use an object (e.g., Guilford, 1967), or how it can be repurposed. Ward, Smith, and Finke (1999), in describing their Geneplore model of creativity (i.e., generate ideas and then explore them), proposed that three of the processes for idea generation are: (1) transformation of ideas into new forms; (2) analogical transfer of ideas from one domain to another; and (3) categorical reduction of ideas. Each of these processes describes how one of the abstracted essences of an idea (form, content, scope) can be modified during the creative cognition process. The application of these ideas from the creativity literature provides a foundation for the generative component of repurposing in the theory of web-mediated knowledge synthesis.

Design literature also contributes to the concept of repurposing. Kress (2000) described how (re-)shaping of the potentials of existing resources leads to transformation of ideas. Similarly, Bereiter and Scardamalia (2003) proposed the concept of a design mode for learning, whereby the goals of learning, are, among others, the improvability and developmental potential of ideas. These ideas of transformation, improvement, and development provide further evidence of the generative capability of repurposing existing ideas. In this way, the design perspective emphasizes that repurposing starts with an existing idea and facilitates its evolution.

Finally, Blooms revised taxonomy (L. Anderson & Krathwohl, 2001; Krathwohl, 2002), recently adapted and presented as Blooms digital taxonomy (Churches, 2008), also supports the notion of repurposing. In the latter model, the primary thinking skills remain intact, but digital terms are provided to detail how emerging technologies support learning. Though many of the terms used to elaborate the model fit within the descriptors of generating, planning, and producing as described in the revised taxonomy, the addition of *remixing* is somewhat unique to the digital taxonomy. Given the affordances of modern digital technology that directly support a remix culture

(Lankshear & Knobel, 2008; Lessig, 2008), this was a timely and relevant expansion of the universe of activity that may comprise synthesis, and parallels the importance of repurposing in the web-mediated learning environment proposed herein.

REINFORCEMENT

The generative value provided by reinforcement also emerged as a key feature in the theory of web-mediated knowledge synthesis. Reinforcementwhen the affordance of multiplicity on the web facilitates a strengthening of the readers emerging knowledge constructionapplies to both information that has been synthesized for meaning and that which results from generative synthesis (i.e., insight or repurposing). In this way, reinforcement can, at different times, facilitate meaning and understanding of web text or be an active part of generative knowledge construction.

Reinforcement of ideas that were originally synthesized for meaning can strengthen them in several ways. First, it can cement ideas in the learners knowledge construction that might otherwise be questionable or unclear. For instance, hard resources can reinforce ideas synthesized from soft resources. Originally ambiguous ideas can also be reinforced by a simpler and more easily understood representation. Conversely, additional details can reinforce ideas that were too simplistic in their original state. All these ways help to facilitate how well the learner understands what he or she has synthesized for meaning. However, if, while reinforcing ideas that were originally synthesized for meaning, the reinforcement prompts elaboration on the original idea that is neither explicit nor implicit in the text, the reinforcement becomes generative.

Reinforcement of ideas that resulted from generative synthesis can be similarly strengthened. For example, if learners question or disagree with the text (which is itself a form of generative insight), their disagreement can later be strengthened if they encounter other resources that similarly disagree, especially if those resources provide a new context or a different perspective. Furthermore, insights that are originally based on background knowledge or idea-play can be reinforced by subsequent web texts. Finally, reinforcement of ideas that resulted from generative synthesis that includes further elaboration on those ideas is itself also generative.

Previous literature supports the value of reinforcement. For instance, rereading is commonly associated with increased recall and comprehension (e.g., Bromage & Mayer, 1986; Howe, 1970; Rawson, Dunlosky, & Thiede, 2000). This explains the value of reinforcement to ideas that previously have been synthesized for meaning. Similarly, revisitation of previously read information has been shown to increase facts learned and strengthen weak connections among the material read (Lawless & Brown, 1997). On the web, users may return to text read previously once it is deemed relevant at a later time (Junivo, 2006; Wen, 2003). They may also return to previously read resources to verify, retrieve, or revise understanding (Afflerbach & Cho, 2009), or revisit challenging ideas after learning more about them elsewhere (Desjarlais & Willoughby, 2010). However, all these perspectives demonstrate the effect of readers choosing to revisit the exact text they have already read.

Reinforcement, as proposed in this theory, is when the same (or very similar) ideas emerge multiples times but in different resources. This is what allows for elaborative and generative potential, often based on the new context, perspective, or time frame of the new resource. Reinforcement is akin to the notion of revisitation and conceptual variability in CFT (Spiro, Collins, & Ramchandran, 2006; Spiro et al., 1992; Spiro & Jehng, 1990), which described how hypertext systems could facilitate flexible understanding through revisiting the same ideas at different times, in various contexts, with different purposes, and from different conceptual perspectives. However, two differences are apparent between the revisitation in CFT/CFH systems and reinforcement as proposed here. First, most CFT and related CFH systems were closed systems with a finite amount of information related to a specific topic. As such, the opportunities for serendipitous or unplanned reinforcement to occur and for these to occur in resources that are topically far afield from the task were more limited in CFT/CFH systems than that afforded in an open online environment. Second, CFT and CFH systems often preselected the themes to be explored as part of the navigational options of the system. In this way, conceptual variability use in CFT and CFH systems promoted a synthesis for meaning of the multiple texts included in the system, the ultimate goal of which was to prepare learners for flexible application of that meaning in new contexts. Alternatively, reinforcement as proposed here is in the context of both synthesis for meaning and generative synthesis. If a web-based reader has an in-the-moment insight that provides new ways of thinking about a particular idea, the reinforcement of that idea later on serves to crystallize and/or adapt that generative insight.

Reinforcement can also demonstrate an affective component that is beneficial to the learners motivation and even his or her learning strategies. If the reader questions or disagrees with the text and this insight is reinforced later by the text, the reinforcement can be encouraging to the reader in a way that may promote even more questioning and disagreement. Similarly, any time the reader is reinforced for synthesizing meaning or generative synthesis, the potential for increased positive affect exists. There may be an impact on self-efficacy (Bandura, 1994); motivation to learn (Brophy, 2004); intrinsic motivation (Deci & Ryan, 1985); flow (Chen, Wigand, & Nilan, 1999; Csikszentmihalyi, 1990); or interest (Hidi & Renninger, 2006). The motivational benefits may be especially relevant for forms of generative synthesis, which involve more cognitive engagement and personal investment than synthesis for meaning.

NOTE-TAKING

An abundance of research indicates that taking notes is beneficial to learning in a variety of contexts (e.g., Kiewra, 1989; E. Kintsch & W. Kintsch, 1996; Makany, Kemp, & Dror, 2009). This theory integrates those findings with data from the study noted earlier and proposes that note-taking is a critical element in the process of web-mediated knowledge synthesis. In DeSchryver (2012), reviewing notes often informed the development of keyword search phrases or prompted insights. Adding ideas to notes (either for meaning or in generative ways) also facilitated the repurposing of those same ideas to other sections of the notes. Finally, conscious idea-play based on the information in notes directly supported generative insights.

Extensive use of notes during the reading-to-do task demonstrated additional benefits to synthesis (DeSchryver, 2012). That is, when the reading-to-learn notes were used through the entirety of the reading-to-do task, they became an additional stand-alone text in the universe of available texts on the web. Ideas from the reading-to-learn notes were at times synthesized into reading-to-do notes for meaning, and other times, generative syntheses were based on reading-to-learn notes. This highlights how one of the potential advantages of online notes is that they integrate well into the web-mediated synthesis environment and become part of the ubiquitous information environment.

This theory proposes that note-taking is a fundamental part of web-mediated knowledge synthesis. This relationship is unique to theories designed to explain online reading. For instance, the TICA (Taxonomy, n.d.) outlines the importance of note-taking for successful online reading comprehension, but in the context of communication. Based on the findings from DeSchryver (2012), note-taking integrates with each and every element of web-mediated knowledge synthesis, directly supporting both synthesis for meaning and generative synthesis.

One of the specific affordances of note-taking that should be considered when using notes for web-mediated knowledge synthesis is their permanence or lack thereof. Some participants in DeSchryver (2012) integrated their reading-to-learn notes as a stand-alone text during their reading-to-do task, in part because they became a permanent part of the web in Google Docs. Combined with the fact that other participants often ignored offline notes from their reading-to-learn tasks (with the exception of what they could recall from memory), this is potentially indicative of the fleeting nature of offline notes in an online world. At the same time, the benefits of offline and online notes varied. For instance, offline notes allowed more free-form information structures to emerge. As such, the value of notes to the in-the-moment processes of web-mediated knowledge synthesis should be considered based on their various online and offline affordances. Using both offline and online notes may be valuable to web-mediated knowledge synthesis. However, the evolution of touch-screen technology and cloud computing may facilitate the merging of offline and online note-taking, rendering concerns over permanence and structure unnecessary.

Finally, note-taking in this environment should also be considered as a broader spectrum of activity than is typically associated with and reading and learning. Though participants in this study did not use many of the new types of online note-taking tools, such as clipping, tags, keyword searching, and inline annotation, these activities and others should be considered in the context of their note-taking value to web-mediated synthesis.

<B>Creative Synthesis

The sequential occurrence of several of the mentioned synthesis elements, including instances in which they are experienced at virtually the same time, results in a new and more or less well-integrated (Bloom et al., 1956) solution to a given task, comprising creative synthesis. It represents a substantially generative way of interacting with web text, background knowledge, idea-play, notes, and the task. As proposed, creative synthesis is essential if web-mediated knowledge is to be constructed in ways that can address the big questions that ill-structured topics pose.

In this theory, the concept of creative synthesis is largely the application of the creative process to reading and synthesizing web texts. The theory moves both scholarly conceptions of reading and creativity in new directions. It opens the definition of synthesis in reading research to more creative and generative examination. It lends a new perspective to creativity scholarship, which is typically explored in the contexts of problem solving, science, inventions, the arts, workplace dynamics, or psychological processes (e.g., Amabile, Conti, Coon, Lazenby, & Herron, 1996; Sternberg & Lubart, 1999; Weisberg, 2006). To be creative (or generative) in ones thinking while reading text (in this case, web text) is a unique perspective on creativity.

However, both bodies of work help to explain the phenomenon that emerged in this study. Reading comprehension scholarship explains many of the skills the participants in DeSchryver (2012) integrated during their creative syntheses (e.g., synthesis for meaning, summary, inference, prediction, and accessing background knowledge). At the same time, the multiplicity of synthesis elements and the creative syntheses documented therein are consistent with Root-Bernstein and Root-Bernsteins (1999) conception of layering their own creative thinking skills one on top of another, often in multiples more than two. Finally, Csikszentmihalyis (1990) notion of flow informs how creative synthesis can be more easily recognized and parsed in a web-mediated environment.

WEB-MEDIATED KNOWLEDGE SYNTHESIS

Together, these elements comprise a theory of web-mediated synthesis. The presentation of these elements is not provided in a purposefully sequential fashion, nor is it intended to imply a linear relationship. Both insights and ideas synthesized for meaning were repurposed or reinforced in the mentioned case studies. The use of divergent keyword search phrases often preceded synthesis for meaning, insights, repurposing, and reinforcement. Alternately, ideas synthesized for meaning were repurposed and reinforced, while insights and notes informed subsequent divergent keyword search phrases. In various combinations, these elements all supported creative synthesis. In sum, analysis of the case studies suggested that all elements of the model could interact and work in concert with others; therefore, a unified theory should account for these interactions and engender further empirical testing of these relationships.

DISCUSSION

Olson (2003) described how theories abstract from the complexity of everyday events and practices (p. 6). They break down complex phenomena into their essences to help others know what to look for, identify how some of the essences are defined in terms of others, and allow for inference and prediction to be made based on these essences. Specific to educational theories, Mishra and Koehler (2006) outlined how once these essences are determined, their value can be viewed through descriptive, inferential, and applied lenses. The theory of web-mediated knowledge synthesis provides specific contributions in each of these areas.

DESCRIPTIVE

The notion of synthesizing information when reading and learning online is a complex and multifaceted phenomenon, and it has proved difficult to observe (e.g., Leu, Zawilinski, et al., 2007). This difficulty may be due to the lack of specificity and clarity regarding what to look for when observing it. This theory endeavors to ameliorate these issues in four ways.

First, as highlighted earlier in this article, one of the primary contributions of this study is descriptive, in that differentiating synthesis for meaning from generative synthesis provides researchers and practitioners alike with a more precise conception of synthesis-related activity than existed in prior literature.

Second, this theory provides several specific details about the conception of generative syntheses that learners and readers may experience on the web. The concepts of divergent keyword searching, insight, repurposing, reinforcement, and creative synthesis further clarify what researchers might look for when observing this phenomenon. Though the activities that these terms describe are not new in the sense that each can be traced to scholarly antecedents, this theory is unique in that it includes all of them as a way to describe one specific phenomenon, that of web-mediated knowledge synthesis. In particular, the borrowing of terminology from the field of creativity research provides additional ways to describe the various forms of synthesis when learning and reading online.

Third, this theory integrates the importance of note-taking (both traditional and nascent online tools that support a myriad of similar processes) in the process of web-mediated knowledge synthesis. Prior conceptions of online learning and reading have identified note-taking as an important component of online reading (e.g., Taxonomy, n.d.), but they did so as a separate process from that of synthesis. From a descriptive perspective, this theory makes the case that it should be difficult to conceptualize online synthesis without considering a variety of note-taking techniques at the same time.

Finally, the theory of web-mediated knowledge synthesis explicitly provides a foundation for appreciating the relational complexity among all its components. While elements of the theory may manifest in isolation (e.g., synthesis for meaning), it is their interrelationships that best describe the complexity of web-mediated knowledge synthesis. In this way, this theory provides a roadmap for observing and describing the components in disaggregated ways, but also emphasizes the importance of considering how each supports or facilitates the others.

INFERENTIAL

While descriptive clarity and emphasis on interrelational activity allows researchers to better see what web-mediated synthesis may look like, it also provides a solid foundation from which to make inferences and predictions about how its elements interact. In this way, it opens up the field to several testable hypotheses that may not have otherwise been considered. Based on the specific description of divergent keyword search phrases, one might predict that extensive and extended use of divergent keyword search phrases will lead to increasingly creative syntheses of knowledge. Similarly, this theory provides a foundation for predictions about the role of soft versus hard resources and task relevant versus far afield resources (e.g., are task relevant resources more amenable to insights or repurposing when compared with resources that are more far afield?). Given the complexity and rapidly changing contexts within which web-mediated knowledge synthesis occurs, myriad inferential possibilities exist. However, this theory provides parameters for the predictions and inferences to be made that may make the process of hypothesis construction more manageable.

APPLICATION

The field of educational research is particularly prone to creating gaps between research and practice, theory and pragmatics. However, as Mishra and Koehler (2006) have noted, a good theory or framework offers us the right level of analysis in order to bridge the gap between description and design (p. 29). In this way, the theory of web-mediated knowledge synthesis offers two benefits to practitioners and those working with them. First, it provides a new lens with which to view existing perspectives of online synthesis. For instance, the TICA (Taxonomy, n.d.) provides an excellent framework for developing questions, locating information, evaluating information, and communicating information from which numerous successful professional development sessions have been run (e.g., Coiro, 2008). The addition of training based on the theory of web-mediated knowledge synthesis to expand on the TICA interpretations of synthesis for future professional development sessions may serve fruitful to practicing teachers.

Second, several ideas from this theory can be reviewed from the perspective of educational change. Given the speed with which the new ecology of information, of reading, of knowledge, of teaching, of learning, and of thinking is emerging, it is not practical for schools to wait for the traditional sequence of theory development, experimental research, and replication to be complete before considering better ways to teach and learn. Consequently, this theory provides an additional perspective through which educators can think about the future of education. The theory of web-mediated knowledge synthesis is largely based on an assumption that educational environments will increasingly move toward one-to-one ubiquitous access to digital devices and that this technical evolution requires a parallel evolution in what and how teaching and learning take place. For those who believe that there will be less emphasis on rote learning and memorization and more time for higher order thinking, this theory provides them with ideas from which to build their vision of the future of education.

Finally, aside from contributing the theory of web-mediated knowledge synthesis, this article also provides a methodological roadmap for future theoretical endeavors. Any phenomenon as complex as synthesis requires literature reviews from multiple schools of thought, as described earlier. The resulting proto-theory provided a new lens for the empirical study, the findings from which modified and extended the proto-theory into the theory of web-mediated knowledge synthesis. This process demonstrates how a dynamic and interactive inquiry process between theory and research can allow research findings to contribute toward building coherent and accumulated knowledge in the field beyond discrete data or information (Koh, 2012, p. 38). Meleis (2007) called this a theory-to-research-to-theory strategy for theory development. Such deliberate use of both a diverse array of literature and empirical evidence to inform theory development should result in more robust theories.

CONCLUSION

Google allows us to be more creative in approaching problems and more integrative in our thinking. We spend less time trying to recall and more time generating solutions.

Paul Jones, University of North Carolina at Chapel Hill

The Pew Internet & American Life Project published this quote in their series about the future of the Internet (Anderson & Rainie, 2010). Several well positioned expertsacademics, business leaders, and government officialsagreed with the sentiment. Eighty-one percent agreed that by 2020, peoples use of the Internet will have enhanced human intelligence. I agree. The potential for advancing knowledge in a web-mediated world is considerable. However, none of these experts explained *how* it would happen. Just because learners have more time to engage in higher order thinking does not mean they know how to do it.

Higher order thinking skills are complex by their very nature. When you add ubiquitous interactions with multiple resources of multiple media types to the equation, the cognitive demands become even more complex. However, the theory proposed in this article provides a foundation for exploring and parsing this complexity. The proto-theory developed from a diverse collection of scholarly work related to synthesis provides that synthesis may result in two very different outcomes. *Synthesis for meaning* is essential to understanding the content provided to us on the web. G*enerative synthesis* allows us to transition from information consumption to knowledge production, in a world where the latter is increasingly critical to informing solutions to complex problems. The final theory that emerged provides several forms of generative synthesis to consider and describes the contexts in which they may occur.

Given the complex nature of thinking in a world where information can be effortlessly and instantaneously accessed, it is clear that one theory cannot fully account for how all knowledge is synthesized. As noted by Ball (1995), disruptive educational theory is at best tentative and unguaranteedit rests upon complexity, uncertainty, and doubt and upon a reflexivity about its own production and its claims to knowledge about the social (p. 269). Consequently, educational theory requires rigorous testing from a variety of perspectives. Research designs must account for the complexity of the field and capitalize on emerging opportunities for data collection. The theory of web-mediated knowledge synthesis needs comparable testing, modification, and adaptation. Yet, as a framework from which to explore and better understand synthesis in the new ecology of learning and thinking, it provides an important foundation.

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