RECONTEXTUALIZING METATEXTUAL KNOWLEDGE AND TEXT STRUCTURE FEATURES IN SELF-REGULATED LEARNING AND ONLINE COMPREHENSION

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ABSTRACT

Dana Z. Copeland: Recontextualizing Metatextual Knowledge and Text Structure Features in Self-Regulated Learning and Online Comprehension
(Under the direction of Jeffrey A. Greene)

Despite advanced and evolving research on the complex strategic decision-making demanded of successful online 21st century learners, many individuals lack requisite knowledge and skills to enact effective strategies, to make inferences, or to engage in self-testing. Researchers across theories and disciplines (e.g., New Literacies, Educational Psychology, and Multiple Source Use) have captured the complex intersection of cognition, metacognition, and motivation associated with learning online. Notably, few researchers have integrated traditional literacy elements related to the structure and function of texts with research on online learning. In particular, there is a need to integrate self-regulated learning literature with research on metatextual knowledge and knowledge of text types and structural features, within online learning environments.

In this study, I applied think-aloud protocol data analysis to examine how metatextual knowledge and self-regulated learning processes related to online comprehension. Using 53 university participants, I explored the following: what kinds of metatextual knowledge were displayed during a complex online science task, the relationship between metatextual knowledge and learning gain, and how self-regulated learning processing varied across text types (e.g., argumentation, refutation). Results indicated the following: (a) learners enacted different processes related to structural and organizational functions of text (b) frequency of use of bold headings statistically significantly related to learning, and (c) a combination of metatextual variables, such as using headings to determine the expectation of the adequacy of content, and noticing lists, statistically significantly related to learning. Further, participants statistically significantly differed in their frequency of self-regulated learning processes (e.g., planning, monitoring, and strategy use) across different text types. Findings from this study align with previous traditional literacy research showing the awareness of structural components of text types related to learners' ability to organize information into main ideas that aid comprehension (Akhondi, Malayeri, & Samad, 2011; Dymock, 2000; Roehling, Hebert, Nelson, & Bohaty, 2017; Wijeckumar, Meyer & Rei, 2012), retention, and recall (Richgels, McGee, Lomax & Shield, 1987). Results implicated potential avenues for more research, including continued exploration of self-regulated learning processes and strategies related to different text types and structural components of online learning. In addition, this study further illustrated the utility of think-aloud protocols as an approach to understanding self-regulated learning in context.

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CHAPTER 1: INTRODUCTION

The use of online materials for learning, both within and outside of schools, has grown greatly in recent years, as has the need for more scholarship on online literacy. Online literacy continues to be in flux (Leu et al., 2013) with the emergence and advance of new theories of online reading and learning (e.g., Leu et al., 2004, 2013; Rouet et al., 2017) as well as new research on necessary skills, knowledge, and processes for successful online learners. Researchers have suggested that because traditional literacy skills alone are insufficient for online learning (Afflerbach & Cho, 2008), both traditional literacy skills and new skills are needed to integrate the complex process of comprehending the vast amount of information found online (Alexander & Fox, 2013; Kuiper & Volman, 2008). Readers on the Internet make strategic reading and learning decisions, engage in multiple reading pathways when choosing which texts to read, and determine how these texts tie to goals (Cho & Afflerbach, 2015). Along with traditional skills such as inferencing and summarizing main ideas, some scholars have suggested an entire new skill set is required to read online—one equipped with skills related to searching for information, evaluating sources, and navigating virtual pathways (Castek & Coiro, 2015; Coiro, 2011a; Coiro & Dobler, 2007). The skills and processes used during online reading and research relate to the context and the nature of the reading environment. Learners adopt multiple strategies to aid their comprehension as they navigate online (e.g., Afflerbach & Cho, 2009; Castek & Coiro, 2015; Cho, 2013, 2014; Cho & Afflerbach, 2015).

The complexities of reading and learning on the Internet are evidenced in the difficulties many readers experience. Struggling online readers fail to enact strategies, lack knowledge of when and where to apply strategies, often fail to make inferences, and fail to activate prior knowledge (Randi et al., 2005). Learners may struggle to comprehend information because they use more surface-level strategies, such as underlining (Hagen et al., 2014), and have difficulty summarizing or pulling main ideas from information they gather across several documents. Learners may experience disorientation as they move in nonlinear pathways by clicking on hypertext links within and across multiple sources (Cho, 2014). Learners may experience difficulty with planning and organization (Azevedo, 2005). Many of these challenges exist for online readers and learners because the multimodal nature of the Internet offers images, audio, video, and graphics from which to make meaning (Gee, 2007; Luke, 2003) and because of the complex knowledge, skills, and practices required when reading online. More research is needed to better understand readers' difficulties online and how to help them learn more successfully.

The challenges related to online reading and learning continue despite several key theories and the work of new literacy researchers who have attempted to capture the necessary skills associated with online reading and learning (Cho, 2014; Leu et al., 2004; Leu et al., 2013). New Literacies theory refers to the self-directed way learners construct knowledge and texts using the skills, knowledge, and social practices that evolve within continuously changing technology contexts (Leu et al., 2004). Leu et al. (2013) identified five key processes for reading and research on the Internet that emphasize the nature of the reading environment and center on the reading purpose or goal. The five key processes are reading to define important questions, reading to locate online information, reading to critically evaluate online information, reading to synthesize online information, and reading and writing to communicate online information. The processes in this model are cognitive processes that are applied to five different types of online reading goals. However, online reading consists of multiple goals and processes not included in this model. Reading goals can also include reading to problem solve, reading for entertainment, or a combination of several of these. Although the cognitive skills associated with these reading purposes are important, Leu and colleagues (2013) failed to consider reader characteristics, such as prior knowledge of a topic or a task, in their model for online reading and comprehension.

Unlike Leu et al. (2013), Rouet et al. (2017) proposed a model for reading multiple documents (e.g., a group of texts written by different authors [Britt et al., 2014]) that incorporates the physical aspects of the task and the social aspects of the reader (i.e., reader characteristics) that affect processing prior to and during reading. The model, reading as problem solving (RESOLV; Rouet et al., 2017), includes cognitive processes and reader characteristics such as prior knowledge that determine readers' decision making (e.g., what to read and how to read it). The reader characteristics included in RESOLV that are excluded in Leu et al. (2013) are important factors to consider because they can influence the ways in which readers process information (Fox, 2009). Physical and social factors are particularly important when reading online in different domains. The RESOLV model is focused on only one reading goal: problem solving. Therefore, use of RESOLV is limited in scope because the model excludes multiple goals associated with online reading and comprehension. Therefore, like the model for online reading and comprehension, RESOLV does not adequately capture necessary components of online reading and learning, particularly in the field of science. The RESOLV model fails to consider metacognitive knowledge as well. Readers require not just cognitive skills and knowledge to decode the text. Readers also require metacognitive knowledge related to the reading task and knowledge of which strategies to use and when to use them. Metacognitive knowledge is the awareness of how individuals think about their thinking, or the knowledge individuals have about how they think (Flavell, 1979).

Self-Regulated Learning

Other skills associated with reading online include self-regulated learning (SRL) skills (Zimmerman, 2000). SRL researchers believe SRL skills relate to multiple document use and comprehension (Bråten et al., 2014; Bråten & Strømsø, 2003). SRL is the "degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning processes" (Zimmerman, 2013, p. 137). Definitions of SRL have evolved since the emergence of the field, from an emphasis on cognition and metacognition (Winne, 1995a, 1995b, 2001; Winne & Hadwin, 1998; Winne & Perry, 2000) to conceptual merging with other domains of research such as motivation (Alexander, 1995). The complex intersection of cognition, metacognition, and motivation within SRL includes knowledge, strategy use, beliefs, and affect (Pressley, 1995). SRL skills encompass how to plan, monitor, and adjust or control learning. These are all important components that contribute to successful learning. SRL also involves social interaction as students engage in learning (Alexander, 1995) and the ways learners interact with texts or others as they construct meaning.

The challenges encountered when reading science documents online (e.g., decisions related to strategy use and source evaluation) and how they relate to learning have been subject to extensive research within the field of SRL. There are four assumptions associated with SRL (Pintrich, 2000): (a) learners actively construct meaning as they interact with their environments; (b) as active learners, individuals control facets of learning inclusive of motivation, behavior, and their environment; and (c) goals and standards are important within SRL as they act as comparisons for the learner to assess if there is appropriate progress being made towards task completion. Finally, (d) SRL is a mediating factor among between learning performance and personal differences readers bring to the learning environment (e.g., motivation, self-efficacy, and prior knowledge) as well as characteristics of the environment (e.g., task conditions and outcome goals).

Many models have evolved over the last several decades of SRL research (Efklides, 2011; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 1995, 2000). These models have targeted differences in motivation and affect (Efklides, 2011) or the role of self-efficacy (Zimmerman, 1995). Most relevant to this study was the model presented by Winne and Hadwin (1998). Learners engage in mental activity prior to starting a task, monitor the progress towards their goals or enact strategies during their learning, and reflect on and evaluate their learning (Pintrich, 2004; Winne & Hadwin, 1998; Zimmerman, 2000). Winne and Hadwin (1998) identified specific conditions (e.g., knowledge about the task, knowledge of domain, individual beliefs, and motivational factors), operations used by learners (e.g., tactics and strategies), products based on performance of the operations (e.g., a goal or plan), evaluations of the products that compare them to expectations students want to meet, and standards. This model captures the cognitive, metacognitive, and individual characteristics associated with reading and learning online. Unlike New Literacies models of reading and researching online (Leu et al., 2013) and RESOLV (Rouet et al., 2017), the goals associated Winne and Hadwin's SRL model are not predetermined, but are left for the individual to define within the context of learning. The broader perspective and approach to learning in Winne and Hadwin's (1998) model best captures the knowledge, skills, and processes for online reading and will be the primary model used in this study.

Researchers in SRL have shown that learners differ in their abilities to self-regulate their learning (Azevedo, Guthrie, et al., 2004) and achieve differently based on self-regulating behaviors (Azevedo, Cromley, et al., 2004; Azevedo, Guthrie, et al., 2004). In a meta-analysis of

45 studies, Fox (2009) found that reader characteristics (e.g., reader ability, domain knowledge, and prior knowledge) vary and therefore, readers' processing behaviors vary. Differences in reader characteristics will influence strategy use and how well readers elaborate on information presented in a text. Therefore, they will impact what and how readers learn from the text. Importantly, other researchers have shown that when SRL is explicitly taught, it enhances learning (Azevedo & Cromley, 2004; Harris et al., 2008; Pressley, 1995). SRL literature also addressed how different and varying strategy use increases learning gains and achievement (e.g., Greene et al., 2008; Greene et al., 2014).

Learners who self-regulate their learning rely on extensive knowledge and use of strategies, active monitoring of those strategies, and strongly developed metacognition (Pressley, 1995). Metacognition includes learners' perceptions of and mindfulness towards their academic competencies and deficiencies, their available cognitive resources required to meet the task demands, and their ability to self-regulate participation in tasks to fully enhance learning (Winne & Perry, 2000). The use of metacognitive monitoring is an integral component of SRL because it allows learners to apply and change tactics or strategies, and therefore to enact control towards better completion of a task in the moment (Winne, 2001). SRL knowledge, skills, and dispositions are particularly important when learning online about science topics.

Science Literacy

Reading online, particularly in science, has multiple and differing goals (Britt et al., 2014). Readers may seek knowledge of a particular phenomenon or gather information about a particular topic. For example, readers may in engage in reading medical websites (e.g., WebMD, the Mayo Clinic website) to gather more information about a medical condition such as heart disease or diabetes, researching climate change for a classroom project, or inquiring about effects of cell phone use on the body. Although science topics have long been explored through school curricula, new standards that are particularly related to science knowledge and skills (NGSS Lead States, 2013) affect how students progress through school, the level of science skills they are expected to develop, and the criteria by which students are considered literate in science.

Reading for understanding of science topics by critically evaluating science content in order to achieve one's goals is called *scientific literacy* (Britt et al., 2014) and requires multiple skills, knowledge, and practices. Reading science topics online includes skills, knowledge, and practices similar to general online comprehension such as synthesizing information from a variety of sources (Goldman et al., 2016) or establishing credibility of a source based on author or date of publication (Britt et al., 2014). The skills and knowledge required by the Next Generation Science Standards (NGSS) for students to meet core competencies in multiple Grade 9–12 science topics are also included and involve: constructing scientific explanations using evidence; evaluating claims, evidence, and reasoning to explain complex interactions; making and defending a claim based on evidence; evaluating the validity and reliability of claims in published materials; and applying scientific principles and evidence to provide an explanation of scientific phenomena (NGSS Lead States, 2013). Students working within a science task use skills and strategies particular to science texts, explaining causal relationships and establishing the usefulness of the content in connection to the goal (Goldman et al., 2016). Scientifically literate readers, or those readers who possess strong skills in reading science documents, exhibit text evaluation skills specific to scientific criteria inclusive of argumentation and explanation for the goal of reading for understanding (Britt et al., 2014). For example, students in Grades 9–12 studying heredity will be asked to "Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors" (NGSS Lead States, 2013, p. 91). Students in Grades 6–8 will be expected to do the following in a unit on molecules to organisms:

> Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (NGSS Lead States, 2013, p. 58)

Learners reading science documents may eventually read material that conflicts with information they have read from other sources or that conflicts with their personal beliefs (Britt et al., 2014).

Multiple objectives of the NGSS involve strategies to engage critical thinking; to increase science content knowledge; and to increase understanding of how to engage in evaluating, critiquing, and explaining specific and complex science content. Students are expected to make decisions that increase skills related to argumentation and to support claims with evidence. These expectations aim to strengthen students' science literacy. However, science education researchers have identified many challenges for teachers in science instruction that include: different instructional approaches based in different analytical frameworks for science argumentation, different instructional emphasis on strategies and approaches to science practices, and differences in assessing argumentation (Henderson et al., 2018). In fact, there are needs centered on developing science argumentation curricula (McNeill, 2009) and how to provide support for teachers integrating science argumentation curricula into classrooms (McNeill & Knight, 2013). Consequently, scientific literacy and how to teach aspects of science literacy require further investigation.

Reading science topics online is another factor embedded in science literacy and instruction. Science topics online are often presented in different genres or media such as in journal articles, blog posts, and websites explaining scientific phenomena with a variety of purposes (Goldman et al., 2016). When viewing scientific documents, multiple data sources of information are presented in addition to the content of the text, including graphs, charts, flowcharts, and diagrams (Britt et al., 2014; Goldman et al., 2016). Scientific documents also contain different organizational features. One common way learners experience the structure of scientific content is through scientific argumentation with three structural features: claim, evidence, and support of evidence (Britt et al., 2014; Goldman et al., 2016), which can create several challenges for both teachers and readers of science.

Metatextual Knowledge

Metatextual knowledge is a cognitive and metacognitive resource available to learners as they participate in a reading task; however, metatextual knowledge has been excluded from the SRL literature and most of the previous literature related to online reading and learning. Metatextual knowledge includes knowledge of different text types and text structure features (Rouet & Eme, 2002). The use of metatextual knowledge during a learning task is one strategic way learners can engage with reading content. Metatextual knowledge is particularly useful for science literacy online as learners engage in multiple texts comprised of different organizational and structural features.

Embedded in the metacognitive aspects of metatextual knowledge is knowledge about text types and structural aspects of texts. Text type knowledge refers to the overall structure of the presented document, such as compare and contrast, descriptive, and problem/solution (Meyer & Ray, 2011). Structural aspects of text include the organization of the text via graphics and logical relations, linguistic cues such as “because,” “furthermore,” and “however,” as well as rhetorical devices, headings, subheadings, titles, and repetition of content to aid the reader in comprehension of presented information (Goldman & Rakestraw, 2000). Structural aspects of reading text such as linguistic cues, rhetorical devices, and headings are also known as *signaling*.

Signaling prompts a reader to pay attention to text content and organizational patterns purposefully used by authors to assist readers (Lemarié et al., 2008). Signaling can include outlines, summaries, headings, bold words, color variation, and other visually represented cues and phrases (e.g., in conclusion, furthermore, because of) to lead the reader to make connections when reading. Reading comprehension researchers who address metatextual knowledge have neither offered a model on text types nor any models on all text structure features. However, one two-component model has been proposed for signaling: Signaling, Available, Relevant and Accessible (SARA; Lemarié et al., 2008). The first component of the model, signaling, is based on the text components themselves (e.g., headings or bold words). The second component, available, focuses on the type of information the signals make available to the reader through visual cues within the text. The next component, relevance, is reader based and emphasizes how the reader takes the available information and determines its relevance to background knowledge and goals. The last component, accessible, pertains to how the reader accesses related cognitive processes. This model is important from a cognitive processing perspective. Learners' use of signaling supports the way they organize information, locate information, and make connections throughout a text (Lemarié et al., 2008). SARA's emphasis on the interaction between the physical components of the text and the ways in which these components cue the reader for cognitive processing made this model the second primary model used in this study.

Researchers of metatextual knowledge have shown that instruction and student exposure to text types and features increases learners' prior knowledge about metatextual knowledge (Pressley et al., 1992). As learners engage in multiple practice opportunities, they gain skills and strategies to aid their development of comprehension (Pressley et al., 1992). Skills and practice include learning how to identify different features of texts such as tables of contents, indexes, and within-text spatial demarcations made visually on the page through the use of section headings (Lemarié et al., 2008). Learners commonly receive instruction on the differences between compare-and-contrast text types and cause and effect, for example, and how to use signal words within texts to determine the structure of a text (Meyer & Ray, 2011). Instruction in metatextual knowledge has been shown to aid in overall organization of information and links to higher levels of comprehension achievement (Meyer et al., 2011; Roehling et al., 2017; Wijekumar et al., 2012). When students utilize metatextual strategies, learners are better able to recall information (Hall et al., 2005; Richgels et al., 1987) and organize information into main ideas and summaries (Akhondi et al., 2011). The use of metatextual knowledge has also shown benefits in the area of reading online (Brand-Gruwal & Stadtler, 2011; Coiro, 2011a; Coiro & Dobler, 2007; Rouet & Coutelot, 2008).

Research on instruction in metatextual knowledge primarily exists within traditional literacy environments, often through examples of informational texts at lower grade levels (e.g., Akhondi et al., 2011; Dymock, 2005; Kelley & Clausen-Grace, 2010). Metatextual knowledge is one example of an important literacy element that should be explored in connection with SRL and the necessary skills, knowledge, and processes for reading science documents in online environments. Reading and comprehending online, particularly in science, is demanding and challenges the reader in complex ways. Science documents often have particular text structure types, such as argumentation, that contain particular structural components (Britt et al., 2014; Goldman et al., 2016). Knowledge about structural components of argumentation texts, skills associated with understanding argumentation texts, and the types of strategies that can benefit comprehension of argumentation texts are important when engaging in reading online to address the complexities of reading across multiple documents. Therefore, students should consider using particular strategies related to metatextual knowledge as a way to enhance their comprehension of science documents. The SARA model provides insight into how signaling cues the reader to engage in cognitive processing to create meaning. Learners' awareness of this knowledge functions on a metacognitive level; therefore, this knowledge is metatextual. Metatextual knowledge should be considered as a potential contributing factor to strategic metacognition during online reading and research and its relation to SRL.

Current Study

In an effort to expand on the ways in which learners comprehend complex science topics during an online task, I explored the types of metatextual knowledge learners displayed as they made meaning from multiple science documents. I evaluated the ways in which learners' use of metatextual knowledge (e.g., use of bold words, headings, signal words) related to comprehension of science topics as evidenced by learning gains.

Furthermore, I analyzed the multiple science documents used by learners as they undertook a science learning task. Documents were categorized by text type (e.g., descriptive, compare and contrast, problem and solution) and surveyed for text structure features (e.g., headings, bold words, signal words). Multiple learners in this study watched a video of an expert describing a science topic using slides to summarize main ideas. They accessed a magazine article that used bold headings to differentiate key ideas of a problem and solution. I explored text types to determine if specific text types related to SRL processing. The following research questions were addressed in this study:

1. What metatextual knowledge do students use during a learning task on a complex science topic?
2. How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?
3. How does the frequency of self-regulated learning processing differ based on text types during an online learning task?

CHAPTER 2: THE LITERATURE REVIEW

Introduction

The general purpose of this study was to examine the ways in which metatextual knowledge related to online comprehension and SRL processes during engagement of a complex science task. I examined the types of metatextual knowledge displayed by learners as they engaged in the science task. I analyzed how the use of metatextual knowledge related to learning gains. In addition, I explored the relationship between SRL and text types. I analyzed text types, their particular structure, (e.g., descriptive, compare and contrast, problem and solution) and text structure features (e.g., headings, bold words, signal words) to determine if these aspects of metatextual knowledge related to the use of SRL processes. More specifically, I determined if the frequency of SRL processes differed by text type. In an effort to situate metatextual knowledge into a conceptual framework, I addressed theoretical and empirical research from online reading comprehension, SRL, metatextual knowledge inclusive of test types and text structure features from traditional literacy, and current scholarship on metatextual knowledge in online reading in the literature review.

Online Reading Comprehension

The understanding of knowledge, skills, and cognitive processes in online reading comprehension, or making meaning while reading online, originates from traditional text comprehension models. Early models of text comprehension showed that several levels of comprehension require interactive processes. These processes include both text comprehension and later recall or summarization of information. In the text comprehension model (Kintsch &

van Dijk, 1978; Kintsch & Yarbrough, 1982), researchers posited there are two levels of processes occurring during comprehension: micro- and macroprocesses. Microprocesses are the local processes related to the understanding of a text as a reader moves from sentence to sentence or phrase to phrase. Macroprocesses exist on a global level as a reader forms the overall general idea or gist of the text as a whole. Strategy use can aid the reader in comprehending and controlling for these different processes.

In the construction–integration model of comprehension, Kintsch (1988) emphasized the cognitive processes readers experience as they interact with text content, form a text base, and access their prior knowledge. At the most basic level, readers engage in surface-level intake of linguistic syntax, or the verbatim intake of words. A text base is a representation of reader input from the words on the page, or linguistic input, with reader inferences that establish meaning from the words. As readers formulate a text base, they take in knowledge, concepts, and information from the text itself (i.e., from the literal words on the page). They form elaborations on this information, make inferences, and create connections by reading further into the text. Initially this text base may lack coherence or be oversimplified. During the integration phase, the linguistic concepts from the text base cue the reader to activate prior knowledge and retrieve information from memory to enhance the text base. The reader will have to make connections and inferences from prior knowledge to create a fuller, more cohesive representation of the concept to form an integrated text. The integrated text base from the construction–integration model is considered a type of situation model. Situation models are the mental representation of the text once other knowledge has been integrated and can be either propositional or non-propositional. Propositions are ideas that can be expressed in words, not necessarily the words themselves. Text bases are always propositional representations of the text, and therefore, a subtype of a situational model. The construction–integration model relies heavily on the cognitive elements related to knowledge construction.

The cognitive processes from traditional text comprehension informs the ways in which online reading comprehension researchers have explored the cognitive elements related to knowledge construction in online reading environments. The skills, knowledge, and processes required in online reading and research have been addressed within New Literacies research. Leu et al. (2013) have established five key processes readers engage in during online reading and research. Reading to define important questions challenges the reader to understand the way in which a problem is framed or to understand the nature of a question. Reading to locate online information requires the reader to know how to choose useful links within a search engine and scan for pertinent information. Skills associated with reading to locate information online include: generating search terms, browsing, critically reading search results and selecting sites, skimming sites for relevance and credibility, selectively reading chunks within and across sites, reading embedded hyperlinks, reading navigation menus, and using text structure cues (Cho & Afflerbach, 2015; Dalton & Proctor, 2008). Readers who critically evaluate online information critique the source information to determine source reliability. Readers synthesizing online information must integrate information from multiple texts as a way to synthesize and in fact summarize across a broad spectrum of reading material. The unbounded nature of the Internet (Coiro et al., 2008) makes synthesizing online information particularly challenging as students navigate through multiple hypertext environments and potentially endless streams of information (Cho & Afflerbach, 2015; Kulikowich, 2008). Scholars have claimed that synthesizing and evaluating information, as well as effectively searching for information, should be considered competencies achieved in primary grades (Leu et al., 2015). Reading and writing to communicate online information challenges the reader to utilize online media such as blogs, emails, and Wikispaces to share information (Leu et al., 2004; Leu et al., 2013; Leu et al., 2015). The processes of reading and research online are expected to be addressed in schools as early as sixth grade and continue through middle and upper levels of education (Leu et al., 2013). With its emphasis on only the cognitive skills related to the processes of reading and researching online, the model of online reading and research fails to capture the full spectrum of the complex skills, knowledge, and processes related to reading and learning online.

It is important to understand the complexities surrounding online reading and research because of the many challenges that learners face. The multimodal nature of the Internet creates different challenges for comprehension because information is presented to users in print, audio, video, podcasts, and graphics, as well as in different media, from newspapers, to live broadcasts, journal articles, hypertext environments, and books (Gee, 2007; Luke, 2003). Each of these contexts presents users with multiple ways to collect and understand information with the virtual click of a button. Online reader pathways generally are nonlinear and move from link to link as opposed to the top-down linear path found in traditional literacy. Online reading requires learners to consider the complexities of how to go about understanding what is read and how reading behaviors and processes differ for online reading and learning than offline reading. When taking into consideration audio, video, and graphic information, the complexity of processing information increases.

Online reading and learning pathways tend to be reader generated and contingent upon hyperlinks embedded within Internet text (Castek & Coiro, 2015; Luke, 2003). Individual reader paths are specific to the context of their Internet reading or learning experiences. Online reading context is actively situated between the reader and the material and varies from reader to reader

(Coiro, 2011a). This context varies because each reader generates their own pathway, making the context and the processes the reader engages in specific to that individual (Coiro & Dobler, 2007).

Nonlinear reading pathways inherent to reading on the Internet require readers to make complex choices and engage in complex processes. For example, structurally, readers may shift from a series of search engine results to a series of paragraphs closely resembling a magazine article on a webpage, to multileveled websites with hypertext, to blog posts, each requiring different and complex skills through which to structurally and organizationally utilize strategies (Coiro, 2011a). Each of these reading environments present different structures and modes of topic organization. Readers navigating these environments need complex skills, such as making inferences and predictions about content within a text, decision making about what texts to read and how to read them, and cognitive and metacognitive strategy use to better comprehend and understand what they read (Cho & Afflerbach, 2015). Monitoring and control within and across online reading environments aids the reader in navigating comprehension challenges. The strong emphasis on monitoring and control within self-regulated learning (SRL; Zimmerman & Schunk, 2011) literature, based on multiple skills and strategies, highlights the complexities surrounding Internet reading comprehension and reading for understanding across multiple sources within reader-generated pathways.

Self-Regulated Learning

Zimmerman and Schunk (2011) defined SRL as the

> processes whereby learners personally activate and sustain cognitions, affects, and behaviors that are systematically oriented toward the attainment of personal goals . . . learners create self-oriented feedback loops through which they can monitor their effectiveness and adapt their functioning. (p. 1)

Connected to this definition are cognitive and metacognitive effortful thinking (Winne, 2011) and motivation (Massey, 2009). Metacognition is "knowing how, when and where to apply strategies to complete tasks successfully" (Joseph, 2005, p. 199).

Learners come to a task with different levels of prior knowledge or even interest in the task, suggesting that context and reader characteristics impact SRL (Alexander, 1995; Fox, 2009). Rouet et al. (2017) claimed readers have multiple personal characteristics from their physical and social environments that can affect their engagement in a task, including prior content knowledge, knowledge, and skills related to reading strategies and knowledge and skills related to decoding written text that impact their decisions while reading. These characteristics create individual variance and as implied, would impact SRL. Learners will vary in their engagement in mental activity prior to starting a task. On a macroprocess level, such as those involved in setting goals or planning, learners will vary in how they monitor the progress towards their goals, and evaluate their learning. Learners' reading behaviors will also vary on a microlevel, such as whether or how they reread a portion of a text or make inferences. Stronger knowledge of SRL processes can enhance understanding when reading complex topics in an Internet environment (Azevedo & Cromley, 2004; Azevedo, Guthrie, et al., 2004) and even predict learning gains (Greene et al., 2014; Winne & Hadwin, 1998; Zimmerman, 2000, 2008). However, despite these strong connections to learning, many students fail to self-regulate their learning (Pintrich, 2000).

Winne and Hadwin's (1998) COPES model was the primary model used in this study; their model captures recursive elements learners engage in during a learning or studying task. Their model consists of the following phases: Phase 1, task definition; Phase 2, goal or planning; Phase 3, enactment; and Phase 4, adaptation. During the task definition phase, the learner develops an understanding of the purpose of the task and considers any limitations or resources available. A learner in Phase 2 constructs a plan for achieving the task that may include specific goals. Phase 3 includes the execution of the plan that may include targeted strategy use to complete the task. During Phase 4, learners adapt or adjust their decisions about learning throughout the task definition, goal setting, and planning phases. In addition, they adapt their learning to future tasks after receiving evaluative feedback. As learners navigate through the phases of this model during a task, they monitor their learning through the use of metacognitive strategies to evaluate their performance within each phase or at the end of the task. Also, students may control which strategies to continue using or when to change based on their internal evaluative feedback during metacognitive thought.

The COPES model consists of conditions, operations, products, evaluation, and standards pertaining to the learning task. Conditions are defined as the circumstances under which cognitive activity occurs. Conditions include both task conditions, with learner knowledge about available resources, and cognitive conditions, that include knowledge and factors, such as knowledge of the task or motivational factors. These factors influence standards for performance and engagement in the task. A learner creates standards for their products or create an ideal or criteria from which to monitor and control for performance. Operations are observed and enacted behaviors that include the use of tactics and strategies learners engage in during a learning task. For example, operations during a learning task on hypermedia may include searching for information, rereading information for understanding, or comparing and contrasting information from more than one source. Products exist as the end result of the operations. Due to the recursive nature of the phases of SRL, products pertain to each phase and include an understanding of the task definition, a plan for engaging in the learning task, or the strategies or tactics used during the task, for example. Learners then evaluate their products to judge their effectiveness. This feedback may come from external sources such as instructors or from themselves as they engage in metacognitive processes (e.g., the process of determining if they understand the material), evaluative decision making (e.g., the determination of whether they have learned the content well enough or not), and metacognitive control (e.g., the decision to change a strategy to suit learning needs) during their learning. Evaluative feedback may include the learner's understanding of how much effort is needed to engage in the task or how difficult the task may be for the individual.

Task Definition

The first phase of Winne and Hadwin (1998) is task definition, whereby the learner identifies the meaning and purpose of the task. Task definitions may be provided by instructors to students. For example, an instructor may ask a student to fulfill specific requirements of an assignment. Conversely, task definitions may be created by learners themselves. Task definitions vary by range and complexity and stretch across domains. In academic environments, for example, task definitions can include researching a topic in literature, completing a grammar worksheet, or studying for a history test.

Task definitions rely on both external conditions (e.g., the wording of the instructions to the task) and internal conditions (e.g., prior knowledge) that influence readers' perceptions and interpretations of the task. External and internal conditions are considered elements of the task conditions (Winne, 2001). Importantly, task definitions may often be ill-structured or poorly defined, leaving students to struggle with a clear understanding of how to proceed (Jamieson-Noel, 2005). Prior knowledge and experience with specific academic tasks influence how tasks can be interpreted (Butler & Cartier, 2004). When learners identify the external conditions and access prior knowledge and experience, they create idiosyncratic definitions of the task to be performed (Winne, 2001). For example, the idiosyncratic definition of a task definition often varies per individual based on the following: different prior knowledge, varying attention to linguistic cues, varying interpretations of the cues, and varying feelings and personal attributes triggered by the task (Rouet et al., 2017).

Structure elements within a task definition provide cues and details within the task to aid the learner in interpreting the task (Jamieson-Noel, 2005). Surface structure elements, such as key or italicized words, provide explicit cues or phrasing to reveal the content or presentation of material. Deeper structure elements, such as what kinds of information will be needed, tie to the purpose of the task. For example, a learner constructing an argument on how best to combat climate change will need to infer how arguments are structured, infer knowledge about climate change, and even infer the knowledge that they may encounter information that conflicts with their personal beliefs. Learners should use both deep and surface structure cues to grasp a full understanding of the task. Identifying deeper structural elements in a task purpose requires the reader to infer meaning, which requires more processing than surface-level cues (Jamieson-Noel, 2005). The ability to interpret structural cues to create a strong understanding of the task influences how readers will then make goals to implement the task (Jamieson-Noel, 2005).

Butler and Cartier (2004) argued that learners' interpretations of task definitions are one component of student academic success. Academic tasks tend to include at least one of the following: task purpose, task structure, and task components. The task purpose, structure, and components contribute to a clear understanding of the academic tasks and link to academic performance. For example, the purpose of a task could be to create an argument as to why a school dress code should be changed. The structure would be to present claims, counterclaims or rebuttal, and supporting evidence based on argument structure. If the task were a debate, the task components would include planning, researching information on the topic, practicing timing for the presentation of key points, and rebuttal points. More simply, task structures such as reading activities cue the reader to engage in prereading, during-reading, and after-reading cognitive activities. Writing structures would feature planning, draft composition, and editing. Future engagement and SRL processes strongly depend on a clear understanding of the task.

Task complexity as assessed by the learner during task definition impacts the planning and implementation phases of learning (Butler & Cartier, 2004). Task complexity is the relative level of difficulty the task entails (Butler & Cartier, 2004). A more complex task may require more effort by the learner and take more time in both planning and implementation than perhaps realized by the learner prior to starting the task (Thiede & Dunlowsky, 1999). Students may feel daunted by a task when they lack a clear understanding of its purpose. Often, they lack knowledge about how to use surface- and deeper level structure cues within the task definition to enhance their understanding. Students experience unfamiliarity with how attention to task definition affects goal setting, planning, and other self-regulatory processes as they engage in a learning task. Teachers can contribute to students' overall attention to task definitions and support student learning by creating well-structured task definitions and offering strategies to learners on how to better comprehend task definitions (Butler & Cartier, 2004).

Researchers have explored the role of task definition in various aspects of SRL processing, and learners have been shown to improve on their task definition over the course of a learning task (Greene et al., 2012). Task definition itself is fluid and evolves based on task complexity as learners engage in different and varying cognitive processes. For simple tasks, requiring lower levels of cognitive processing, learners engage in more shallow task definitions, plans, and goals than for complex tasks. As tasks became increasingly complex, corresponding task definitions, plans, and goals deepen (Pieschl et al., 2014). Similarly, learners make judgements about how deeply they will engage in content based on the difficulty of task definitions. Learners predict they will engage in more elaborate and deeper cognitive processing (Bromme et al., 2010). If they judge a task to be more complex, they engage in planning more frequently and plan harder (Bromme et al., 2010).

One explanation for these findings could be that as learners gained more knowledge about the content, their task definitions became more refined. Refining the task definition as students engage in the task provides support for the recursive nature of the Winne and Hadwin (1998) model. Learners do not move linearly from one phase to the next, but through SRL processes, circle back to different phases of task definition and planning or goal setting as they move through content in Phase 3.

Goal Setting and Planning

During the goal setting and planning phase of SRL, learners establish an initial set of standards and a plan for performance of the task prior to performing the task. Goals and plans can also be adjusted once learners engage in the task. Individual characteristics such as interest, motivation, and knowledge, as well as time constraints and available resources will impact learners' standards and plans. A learner's goal orientation (i.e., reasons contributing to task performance; Dweck, 1986), is one individual characteristic learners bring to the context of the task. Goal orientation for the purposes of academic tasks can best be described using achievement goal theory (Pintrich, 2000). Early research in goal orientation has shown types of goals to have a positive impact on performance in both academic and nonacademic tasks (Kitsantas et al., 2004). More specifically, mastery goal-oriented learners who focused on the process of learning over the outcome positively impacted their performance of the task (Kitsantas et al., 2004). Zimmerman and Kitsantas (1997) found that shifts in goals during tasks are important to consider in relation to self-efficacy (i.e., perceptions of ability). Results indicated an increase in female participants' self-efficacy for those who shifted from process to outcome goals after instruction in dart throwing. This suggested that after the process of the task is practiced, a mental shift with an emphasis on the outcome increases self-efficacy. Those female participants with the lowest self-efficacy focused solely on outcome goals. Goal-orientation researchers have shown connections to skills and strategy use (Bernacki et al., 2012; Duffy & Azevedo, 2015) and performance on academic tasks (Kitsantas et al., 2004; Zimmerman & Kitsantas, 2002). In addition, goal orientation within academic tasks reflects the standards or expectations behind evaluative processes learners engage in to determine their success on a task.

Goal orientation contributes to the understanding of how learners engage with a task. Mastery-approach oriented students have been shown to use more strategic processes throughout the learning task than students of other goal-orientation approaches (Zhou, 2013). In more recent research, Duffy and Azevedo (2015) explored the influence of achievement goals and scaffolding on SRL processes and learning. They found that learners who received scaffolding in the form of prompts and evaluative feedback from an intelligent tutoring system during a learning task used more strategies during a learning task in a hypermedia environment. This increase in strategy use had little impact on achievement. When looking further into achievement goal orientation, results indicated a significant interaction between different goal orientations and the conditions of achievement. Learners with a performance approach to goal orientation performed at higher levels of achievement under the prompt and feedback conditions. Students with mastery-approach goals, who focused on which strategies or methods to use during a task, did not perform at higher levels when they received scaffolding. The researchers offered that these students may have felt the scaffolding was intrusive or too controlling and may have performed better with fewer or none of these intrusions. The significance of these findings indicates that goal orientation, and individual levels of motivation, may impact what types of feedback work with what students and in what circumstances.

Bernacki et al. (2012) investigated the relationships between achievement goals and the ways in which achievement goals may influence strategy use and academic performance in an online learning environment. Bernacki et al. (2012) predicted that learners who approached tasks with higher levels of mastery goal orientation would engage in higher levels of self-regulated behaviors than learners with performance goal orientation. Learners with higher levels of mastery goal orientation exhibited particular strategy use including taking notes, exploring hyperlinks to further seek information, and tended to monitor their progress towards their goals. These same SRL behaviors were not predicted by performance goal-oriented learners.

The types of goals learners set and the way they approach the learning task based on goal orientation will impact planning of the task. Planning includes the general ways in which the learner will approach the task. Thoughtful plans will require the reader to access prior knowledge and recognize knowledge gaps. These gaps will contribute to plans about how to approach a learning task. Thoughtful planning considers task definition, goal setting, and standards of performance.

Little research on planning exists in SRL literature. Eilam and Aharon (2014), however, performed a qualitative longitudinal study of ninth-grade student groups. Participants were placed into fixed groups of three to five learners with similar science abilities ranging amongst low, medium, and high. Observational notes and discourse analysis during group interactions provided the bulk of the data analysis to determine SRL behaviors exhibited during planning, monitoring, and making plan adjustments throughout the course of the task. Data was also collected from participants' use of daily and yearly planning reports that documented time management and planning activities towards completion of the task. The yearly planning reports provided learners with suggested planning activities, (e.g., choosing a subject or gathering information) and space for learners to record what plans were enacted during the task. The daily planning reports broke down daily planning tasks into suggested, manageable time chunks with space for learners to record the actual amount of time spent on the tasks.

Results indicated eight types of behaviors related to planning, monitoring, and making plan adjustments. Learners needed time to adjust to the habit of planning. Extensive time was needed for learners to consider alternatives to how to reach goals and come up with plans. Time monitoring and checking schedules contributed to most of the monitoring of progress towards learners' goals. Learners became increasingly aware of cues (e.g., task-related cues presented in the daily and yearly planning reports, teacher expectations, and personal cues such as fatigue or boredom) as the task progressed. Learners were able to adjust plans by doing work at home, scheduling outside meetings with the group, or changing their work habits. As progress towards their goals increased, learners were able to plan further ahead in the task. Learners were also able to manipulate their plans (e.g., set a higher goal). This study was important to consider for individual students as well as for short-term tasks.

Other researchers have shown the relationship between planning and writing. Graham (2006) showed that planning impacts writing. Results indicated that skilled writers devote more attention to planning prior to writing than less-skilled writers. In addition, as writers develop and gain writing experience through schooling, they become more conceptual in their planning. Results also showed teaching writers to plan had a positive impact on improving writing.

Enactment of the Task

In the third phase of the Winne and Hadwin (1998) model, the learner implements the plan and enacts the actual learning task. During the enactment of the task, SRLs monitor and control their learning. Monitoring involves monitoring both performance and cognition. Monitoring performance involves comparing products of performance to the standards set up within the task definition and goal setting phases. Monitoring cognition includes judgements of how well the learner understands or comprehends the information they have read. Learners working through the enactment of a learning task engage in monitoring and evaluating their learning process, but also circle back to consider task definitions, goals, and plans (Coiro, 2011a; Coiro & Dobler, 2007). Learners tend to enact strategies, which are integral to effective control, to control their learning. Once learners establish that they may not understand the content they have read after monitoring their reading comprehension, they may decide to implement or change a strategy to control for their comprehension. SRL includes using various types of strategies to meet a variety of purposes and goals while making decisive choices to control reading behavior contingent on goals. Readers will modify or change their reading goals as they progress through the material (Minguela et al., 2015).

Strategy Use and Self-Regulated Learning

A strategy is an individual's intentional use of procedural knowledge during a specific task. The efficacy and efficiency of strategies can be monitored and controlled, such as when their usual thought or behavior is judged to be working ineffectively (Harris et al., 2008). Reading comprehension strategies such as summarizing or asking questions are best used in a consistent and flexible way and through direct teacher instruction of self-regulation strategies (Harris et al., 2008; Pressley, 1995). Researchers have suggested that effective strategy use requires multiple practice opportunities (Pressley et al., 1992).

Strategy use during SRL can be linked to achievement. Greene et al. (2008) examined the role of SRL strategies of gifted and regular-level middle school students performing a complex science task. Results indicated that differences existed in the cognitive learning gains between groups, with gifted students performing at higher levels. Results also showed that gifted students in middle school had higher frequencies and more engagement in the effective use of strategies. Results linked the relationship of higher level students' use of self-regulatory strategies to their higher learning achievement. Greene et al. (2014) examined the role of SRL macroprocesses such as planning, monitoring, and the use of strategies that could best enhance learning in a hypermedia environment. Greene et al. (2014) found that frequent use of elaboration strategies predicted learning gains in knowledge.

Elaboration strategies, particularly knowledge elaboration and inferencing, have also been connected to more accurate understanding during the learning of a complex science task in a hypermedia environment (Greene & Azevedo, 2007). Greene and Azevedo (2007) found that controlling for their learning environment by clicking on a new information source predicted participants' cognitive understanding. Learners with more frequent clicking on a new information source may have indicated a lack of clear goals within the learning task. Learners who monitored their understanding predicted the usefulness of content. Learners who had higher cognitive shifts showed higher frequencies of predicting usefulness of content. In addition, the learner's realization that they recognized content but were not able to recall the information in the current context also created positive shifts in cognitive understanding. Learners exhibiting higher frequencies of these feelings of knowing had higher levels of cognitive shifts during the enactment of the task. These results indicated the important role monitoring and control strategies play in understanding information, which can link to achievement in learning tasks on the Internet.

The role of prior knowledge and its connection to SRL strategies is important to consider within the larger picture of comprehension. Taub et al. (2014) found that when students performed a complex science learning task in a hypermedia environment, levels of prior knowledge impacted how SRL strategies were used, sequences of SRL strategy use, and the frequency of SRL strategy use. Students were rated as having low or high prior knowledge before they performed the task. Results indicated that students with high levels of prior knowledge exhibited significantly higher levels of overall strategy use. Specifically, those learners with high prior knowledge used more metacognitive strategies than low prior knowledge learners.

Taub et al. (2014) also found different strategy patterns between high and low prior knowledge learners. Learners with high prior knowledge engaged in sequenced patterns of metacognitive strategy use followed by cognitive strategy use. For example, the most frequent pattern of high prior knowledge learners involved planning, prior knowledge activation, judgements of learning, and summation. The most frequent pattern for low prior knowledge learners involved planning, prior knowledge activation, summary, taking notes, and feelings of knowing (i.e., a student's recognition that they had come across the content in the past but could not recall). These differences in patterns suggested that low prior knowledge learners prioritized cognitive strategies to understand the material, whereas high prior knowledge learners were able to capitalize on their prior knowledge and take their reading to a higher level with metacognitive strategy use. Lastly, Taub et al. (2014) determined that students with high prior knowledge exhibited more time spent using SRL strategies.

Training in SRL processes can foster increases in the use of learner planning, prior knowledge activation, and use of self-regulatory strategies (Azevedo & Cromley, 2004; Azevedo, Cromley, et al., 2004; Azevedo, Guthrie, et al., 2004). Pressley et al. (1992) recommended a transactional approach to teaching strategy use to students consisting of multiple components. This approach includes the use of teacher modeling, support from teachers via scaffolding that is faded out as learners gain knowledge and independence, effective self-regulation, and metacognitive strategies. Scaffolding with explicit self-regulation prompts, such as reminders to use a targeted strategy, benefits readers who struggle with reading comprehension (Mason et al., 2013). Teacher scaffolding and prompts have also been shown to increase the use of SRL strategies and facilitate learning (Azevedo, Cromley, et al., 2004).

Strategy Use in Reading and Research in Online Comprehension

Researchers who study comprehension during online reading and research have emphasized many of the skills and strategies required for Internet comprehension. Skilled Internet readers incorporate active and flexible online monitoring strategies to meet reading goals and purposes; make goal-oriented efforts to control reading behavior; and examine, modify, and revise reading goals and actions (Cho, 2014; Cho & Afflerbach, 2015; Minguela et al., 2015). However, many struggling readers lack the knowledge of when to use particular strategies and where to employ them (Randi et al., 2005). In fact, many struggling readers neglect to even activate their prior knowledge (Randi et al., 2005).

Several types of intertextual strategies remain important when reading on the Internet (Afflerbach & Cho, 2009; Cho, 2013, 2014). Intertextual strategies are strategies readers use when reading more than one document to integrate meaning across documents into a cohesive whole. Intertextual strategies include identifying and learning important information (e.g., synthesizing, linking, and analyzing information across multiple sources), monitoring progress towards reading goals, and evaluating information and its sources (Afflerbach & Cho, 2009; Cho, 2013). When locating, evaluating, and synthesizing content across websites and within search engines, skilled readers engage in complex, multilayered inferences as they predict content in forward thinking ways (Coiro & Dobler, 2007). Intertextual strategy usage that aids comprehension includes deep level strategies such as comparing, contrasting, and corroborating content across multiple documents (Bråten et al., 2014). It is important to note that individuals differ during reading phases and therefore strategy use, effort, and processing per individual may vary (Bråten et al., 2014).

Strategic Internet readers engage in reading activities to identify links and use search terms based on their task purpose (Cho, 2014). Internet readers have to evaluate the usefulness of their search links, determine which texts may be useful, and anticipate how well the texts fit task goals (Cho, 2014). Hyperlinks embedded within texts offer opportunities for readers to enhance their understanding of presented information but also take readers onto different paths. This may cause disorientation. Successful Internet readers must regulate their learning paths to prevent disorientation (Cho, 2014).

Strategies used to monitor and control for comprehension across multiple documents include both surface-level strategies such as memorization or paraphrasing and deeper level strategies such as elaboration, summarizing via meaningful notetaking (Hagen et al., 2014), and comprehension confirmation (Bråten & Strømsø, 2003). Elaboration strategies often include self-explanations where the reader reasons through a concept or links new information to prior knowledge (Goldman et al., 2012). Hagen et al. (2014) found that deeper and more integrated strategy use, such as making connections through note taking and summarizing material, resulted in higher levels of comprehension. The use of elaborative strategies during note taking, in particular, increased comprehension of a complex science argument. The use of surface-level strategies such as paraphrasing during the reading of multiple documents resulted in lower levels of learner comprehension. Bråten and Strømsø (2003) tracked the progression of student learners as they engaged in reading multiple documents to find that learner strategies changed from simple strategy use (e.g., memorization of content) to deeper strategy use (e.g., elaboration) as the learners progressed. This research supported the idea that during initial reading of challenging content, learners may use more cognitive strategies. As readers become more skilled, they enact deeper metacognitive strategies.

Strategy use particular to online learning tasks includes strategies applied to source information and attention to sourcing. Learners may use source information during reading to predict content and use dates of their sources to evaluate the quality of information and veracity of content (Britt et al., 2014). Attention to sourcing includes evaluating sources for trustworthiness, making judgments about the relevance of the source information, and assessing the credibility of the source (Goldman et al., 2012; Strømsø et al., 2013), as well as evaluating in-text citations (Strømsø et al., 2013). Not only do learners pay attention to sourcing of a document they have selected to read, but they also note intertextual citations. Attention to sourcing within the text is when sources are cited intertextually, or within the reading material (Strømsø et al., 2013). Attention to intertextual citations when using multiple documents has been shown to positively impact cross corroboration of content (Strømsø et al., 2013).

Learners also evaluate sources for reliability as they read (Goldman et al., 2012) and evaluate the relevance of content to the task definition (Britt et al., 2014). Evidence of source reliability includes whether the source has been vetted by a professional community or appears in a well-respected journal. Learners evaluate their own progress towards their goals and their understanding of the content as they engage in monitoring strategies and retrieve and integrate various forms of information throughout their reading (Lazonder & Rouet, 2008). Metatextual strategies also exist but will be addressed in a later section.

Adaptation

Phase 4 of the Winne and Hadwin (1998) model focuses on the decisions that learners make after engagement in the learning task. Learners make decisions after receiving evaluative feedback after the task is completed so that they can apply what they have learned to future work. For students in an academic environment, final evaluative feedback most likely comes from peer review and teacher feedback after the product is completed. The learner, ideally, reflects on the feedback and stores what was learned as knowledge, which can be activated at a later time when they engage in similar tasks. Effective learners access this prior knowledge and adapt it to the context of the new task. Notably, students performing a task also make decisions and adapt their learning as they engage in task definition, goal setting, and planning and enactment of the task that will improve their understanding throughout the first three phases of Winne and Hadwin's model. During each phase, learners evaluate and compare their standards of performance to their actual performance. For example, a learner may find that after they enact a reading task and gain a stronger understanding of the content, they may go back and revise their task definition or adjust their plan.

The research pertaining to adaptation in SRL is rather limited, with studies focusing primarily on adaptation within other phases of SRL. Pieschl et al. (2012) examined the relationship between adaptation and performance. Pieschl et al. (2012) have been referred to as the first researchers to examine the relationship between adaptation and performance in an authentic learning environment. Pieschl et al. (2012) asked 119 participants to perform three tasks ranging from complex to simple, requiring varied levels of cognitive processing. This study explored whether learners adapted their learning between tasks as the tasks became more complex and whether this adaptation benefitted task performance. Participants showed significant between-task adaptation. As they engaged in a simple task, a complex task, and then a simple task, they adapted their learning processes. Participants performed deeper levels of processing on the complex task. However, these changes in processing showed no consistent effects on learning performance. Additionally, Pieschl et al. (2012) and Bromme et al. (2010) found that as task complexity increased, participants in their studies adapted their task definitions, plans, and goals to reflect deeper cognitive processing.

The ways in which learners adapt their levels of processing to meet different levels of task complexity is important to consider as learners perform different tasks, particularly when reading online. Learners should be expected to encounter varying levels of complexity when reading in different online formats such as blog posts, newspapers, or medical journals that require various strategic and adaptive processes. SRL models may provide some insight into potential paths for exploring these relationships.

SRL models offer a useful framework from which to examine learning in Internet environments. The recursive and iterative processes within SRL center on the interaction between the text and the learner. The multiple processes of defining, planning, monitoring, and adapting to the learning environment, along with the strategies, skills, motivation, and engagement represent the strong social nature of learning on the Internet and, more importantly, represent what successful self-regulated learners do (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2000). The social nature of learning on the Internet includes SRL processes that embody the interactions readers have with texts and within themselves that combine with the knowledge they gain during the learning task. Learning on the Internet, or simply reading content, is not just a learner decoding words, but includes active meaning creation. Readers create meaning through a combination of the prior knowledge they bring to the learning task, the inferences they apply to the words, and the motivation and self-perceptions they bring to the task (Kintsch, 1988). The social nature of learning on the Internet draws attention to the individual differences readers bring with them as they engage in learning. It also highlights the importance of measuring SRL.

Measuring Self-Regulated Learning

Attempts to measure SRL have historically met with several challenges. One way of measuring SRL is through the use of inventory-style self-reports (Winne, 2010). Inventory self-reports take place in a one-time context after a learning task is completed as opposed to throughout the entirety of the learning task (Winne & Perry, 2000). Learners who self-report in this manner, therefore, do not always accurately capture their thoughts or effectively retrieve them from memory (Winne & Jamieson-Noel, 2002). In addition, because of the contextualized nature of SRL within a learning task, where SRL processes change within and across phases, self-reports may not accurately reflect instances of SRL during a particular task (Winne, 2010). Often, self-reports involve learners evaluating their processing on a Likert scale, which confines their rating to five to seven possible response options, and only for the particular processes captured by each item. The validity, then, of measuring SRL in this way is questionable (Winne & Perry, 2000) as not all possible responses may provide an appropriate fit, leaving participants to choose a rating most closely related to their experience.

Think-aloud protocols (TAPs; Ericsson & Simon, 1993) are another form of methodology many SRL researchers have utilized to measure SRL processes (e.g., Azevedo, 2005; Greene & Azevedo, 2007, 2009; Greene et al., 2014). TAPs are a data collection method where participants speak aloud their thought processes and actions as they undertake a task (Greene et al., 2018). TAP data affords insight into the cognitive and metacognitive processes participants engage in and how these processes relate to behavior during learning (e.g., Greene & Azevedo, 2007, 2009; Greene et al., 2014). Unlike inventory self-reports, use of TAPs captures SRL processes throughout the task, as opposed to after task completion when learners may not remember each particular thought they engaged in (Greene et al., 2011). This is one of several benefits of using TAPs in comparison to other collection methods. Verbalizations uttered concurrently with task performance provide insight into processes in a real-time context so that learner thoughts are captured in the moment and in the particular context in which they occurred (Greene et al., 2011). TAP data has shown how SRL varies across different contexts and within individuals (Greene et al., 2018).

The utterances made by participants during a learning task generally fall into three categories (Ericsson & Simon, 1993). Type 1 verbalizations include explicit statements about cognition using language that directly represents the cognitive process the participant experiences. Type 2 verbalizations are explicit statements about cognition that relate to senses outside of language intake. For example, a participant may utter that they see a chart or graph. Type 3 verbalizations refer to explicit statements the participant makes referencing what they are thinking or why they are performing a particular action. Researchers have argued that Type 3 verbalizations influence learners' cognitive processing and subsequently, performance on the task. However, evidence has suggested Type 1 and 2 verbalizations do not interfere with cognitive processing (Ericsson & Simon, 1993).

Ericsson and Simon (1993) cited multiple studies in which Type 1 and 2 verbalizations showed no interference with cognitive processing. These studies consisted of complex tasks such as problem-solving tasks (e.g., Ericsson, 1975; Flaherty, 1974; Newell & Simon, 1972; Roth, 1965; Walker, 1982), decision-making tasks (e.g., Carroll & Payne, 1977), and recall of information tasks across a variety of contexts. Researchers have also collected participants' verbalizations while they engaged in physical tasks that involved manipulating objects and verbalizations within visual perceptual tasks (e.g., Goldner, 1957; Thomas, 1974) that involved what a participant visually saw. When Ericsson and Simon's procedures for Type 1 and Type 2 verbalizations were strictly followed, study findings suggested that verbalization did not interfere with the course or the structure of participants' thought processes. Strict procedures for eliciting and producing TAPs are important to capture data effectively. These include: providing clear instructions, allowing time for participants to practice, and providing prompts when a participant fails to think aloud for more than several seconds (Greene et al., 2011; Greene et al., 2018). It is important to follow these procedures when using TAPs to limit interaction between the researcher and the participant (Greene et al., 2011; Greene et al., 2018). TAP data is often captured through audio and video recording and then transcribed and coded. Coding is addressed more thoroughly later in this review.

Summary of Self-Regulated Learning

SRL is an important component of reading and research online that includes the cognitive, metacognitive, and motivational processes learners engage in throughout a learning task (Zimmerman, 1995, 2013). Winne and Hadwin (1998) offer a model that proposes learners move through phases in which they define the task, set goals and plan, undertake the task, and adapt as they experience conditions, perform operations, create products, and evaluate their products against a set of standards. Approaching online learning from this SRL perspective has generated valuable insight into the complex knowledge skills and processes involved in reading and research online, particularly as it relates to science learning. Although researchers have explored the relationship between goal orientation and strategy use (Bernacki et al., 2012), planning and SRL processes (Eilam & Aharon, 2014), and within-task adaptation (Bromme et al., 2010; Pieschl et al., 2012), a large amount of research has centered on the use of strategies during the enactment of a task. Researchers within SRL have focused on strategy use during reading and online research and have contributed to the overall understanding of skills and processes required for successful Internet reading (e.g., Azevedo & Cromley, 2004; Azevedo, Cromley, et al., 2004; Azevedo, Guthrie, et al., 2004; Pressley et al., 1992). Measuring SRL using TAPs is one effective way to capture the cognitive processes learners engage in as they perform a learning task and the motivational factors that contribute to performance. Despite the multiple studies examining SRL, little emphasis has been placed on the role of metatextual knowledge in SRL and online reading.

Metatextual Knowledge

Metatextual knowledge is a person's knowledge about texts and text comprehension activities (Rouet & Eme, 2002). Embedded in this definition are elements of text structure. Text structure can be defined as the structural aspects of reading text that assist readers in comprehension (Goldman & Rakestraw, 2000). Structural aspects of text include how the text is logically and relationally organized, semantic cues such as "because" and "however," and structural devices such as headings and titles that assist readers with comprehension (Goldman & Rakestraw, 2000). Extensive research on text structure and metatextual knowledge existed in the reading literature dating back almost a half century. This research was embedded within instructional strategies research (e.g., Hiebert, 2013; Meyer et al., 2010), related to cognitive processing (e.g., Kintsch, 1974; Kintsch & Van Dijk, 1978; Kintsch & Yarbrough, 1982), and was often targeted specifically to expository texts (e.g., Akhondi et al., 2011; Dymock, 2005). As early as the 1980s, textual strategy use, known at the time as rhetorical strategy use, was understood to aid a learner with the formulation of an overall gist (Kintsch, 1988) of the content, or macrostructural comprehension (Kintsch & Yarbrough, 1982). Rhetorical strategy use was one way to exhibit control within the reading environment. More recently, with the increased use of hypermedia environments, several scholars have addressed the role of metatextual knowledge while reading on the Internet (e.g., Rouet & Coutelot, 2008; Rouet & Eme, 2002) and embedded metatextual strategy use within general strategies use during Internet reading (e.g., Coiro, 2011a; Coiro & Dobler, 2007).

Print literacy research on text structure has shown the use of bold words, headings, and other organizational features of text presentation engages readers in main ideas, allows them to make connections, and aids in their acquisition of knowledge when reading expository texts (Akhondi et al., 2011). Students with a strong understanding of text structure features will often have stronger comprehension of the material (Dymock, 2005). In fact, good structural (i.e., rhetorical) form provides the reader with appropriate signals to elicit the correct rhetorical schema and make the structure explicit. Text structure features and rhetorical strategy use aid in comprehension so that a more optimal organization of the text can occur for the reader. Comprehension can still occur without this structural schema activation and strategy use but may be achieved in a less optimal way (Kintsch & Yarbrough, 1982).

Despite the strong links between the use of metatextual knowledge and text structure features in traditional literacy, few studies existed connecting metatextual knowledge and text structure features to reading and comprehending information on the Internet (e.g., Coiro & Dobler, 2007; Rouet & Coutelot, 2008; Rouet & Eme, 2002). In her theoretical paper, for example, Coiro (2011b) identified key instructional components when framing practice with online website structures for students. Coiro (2011b) claimed that skilled readers navigate different website structures and multiple modes of information. These behaviors require skills and strategies related to complex decision making such as, corroborating claims across multiple documents and informed choice-making to judge which ideas are important. Surprisingly, metatextual knowledge and text structure features played little to no role in the SRL literature. Integrating simple elements of text structure features and metatextual knowledge with the SRL processing readers engage in before reading, during reading, and after reading could inform learners' engagement in organizational, summative, and connective strategy use across multiple sources during reading on the Internet. In addition, there were surprisingly few studies on text structure types in relation to learning online.

Text Structure Types

Meyer and Ray (2011) identified six text structure types in single informational texts that involved signaling (i.e., visual representations to prompt a reader to pay attention to the content of the text; Lemarié et al., 2008): comparison, problem and solution, cause and effect, sequence, collection, and description. In comparison text structures, the author organizes main ideas into differences and similarities and uses signal words such as "but," "however," and "alternatively." In problem and solution text structure types, ideas are organized in ways that present the problem and then the solution or answer to the problem. These text types include signaling words such as "problem" or "puzzle" to help readers identify the explicit problem and signal solutions to the problem with phrases such as "to solve these problems," "solution," and "in response." In cause and effect text structure types, ideas are organized based on causation. Cause and effect text types indicate causation via key words such as "cause," "bring about," "produce," "explain," and "consequently." In sequence text structure types, authors organize ideas in relation to time and use words such as "first," "finally," "later," and "recently." Groups of ideas are often organized numerically in collection text structure types, in description text structure types, ideas are organized by description of attributes and use of signal words such as "properties," "attributes of," and "characteristics." Identification of specific text structure types can enhance reader comprehension by cuing readers to main ideas and enhance memory or recall of important concepts within texts (Meyer et al., 1980). Meyer (1975) examined whether the organization of text structure types such as causation or comparison had a greater impact on memory than those less-organized types such as description. Results indicated that more organized text structures with implicit hooks for memory, such as problem-and-solution, contributed to learning and memory over a structure of description, that simply describes a topic.

Meyer and Ray (2011) failed to include common text types such as argumentation and refutation that are important to science learning. Because the context of the current study was a learning task on a complex science topic, science texts are addressed. Science reading presents multiple challenges because of its complexity and emphasis on argumentation and explanation as opposed to searching for information (Britt et al., 2014). Skills and reading processes and behaviors particular to science texts include synthesizing different views on a topic, supporting an argument, explaining causal relationships, determining the credibility of various sources, and establishing the usefulness of the content in connection to the goal. Reading in science also includes interpreting scientific texts and data and using diagrams and patterns of inquiry (Goldman et al., 2016).

When reading science texts, it is important for the reader to activate prior knowledge before and during the task, so they are primed to engage in reading behaviors targeted to science texts and are primed to find useful information related to argumentation (Britt et al., 2014). Because the current study included a learning task based on a complex science topic, relevant details about argumentation texts are included in this review. Argumentation texts in science answer how-you-know questions by making claims and explaining those claims with reasoning (Britt et al., 2014). Argumentation texts are structured in the following way: presentation of a claim; support for the claim through explanation, reasoning, and evidence; and presentation of a counterclaim. Counterclaims, or statements that refute the scientific claim, are not always present in argumentation texts (Britt et al., 2014). Prior to reading and during reading, science readers' goals should include being able to identify the claims and counterclaims and support and reasoning for them (Britt et al., 2014).

Because science texts often contain information that conflicts with readers' prior knowledge, refutation texts are also considered in this review. Refutation texts are another text excluded by Meyer and Ray (2011). Refutation texts are a text type commonly used to explicitly identify common misconceptions on a topic. The purpose of refutation texts is to challenge readers' prior knowledge by stating correct beliefs and promoting conceptual change (Alvermann & Hague, 1989; Chambliss, 2002). Several studies (e.g., Alvermann & Hague, 1989; Alvermann & Hynd, 1989; Kendeo & van den Broek, 2007) examined the role of prior knowledge in refutation texts. Results indicated that prior knowledge activation alone will not suffice when addressing beliefs stated in a text. Explicit statements alerting readers to misconceptions and refuting common beliefs and explanations as to why these beliefs are incorrect increase the likelihood that readers will engage in conceptual change. Conceptual change occurs when individuals revise their initial, primitive everyday perceptions of the world within their current mental representations; it often occurs after a purposeful educational experience (Murphy & Mason, 2006) grounded in evidence-based concepts (Murphy & Alexander, 2016). Essentially, because of the structure of refutation texts, which explicitly reference differing beliefs, readers are likely to gain specific knowledge pertaining to a topic in a purposeful educational experience.

Learners should be exposed to different science text types and be provided opportunities to practice. Researchers suggest that as children get older, they gain exposure to a wider variety of text types and experience difficulties with some types over others. Sixth-grade students, for example, had more awareness of compare/contrast text types than causation types (Richgels et al., 1987). Englert and Hiebert (1984) found third graders had more text type and text feature knowledge than younger students. Englert and Hiebert also found that description and compare/contrast text types were most difficult for students, and students in Grades 3 through 6 acquired the most knowledge in the description text type. In their study comparing good readers and readers with learning disabilities, Englert and Thomas (1987) found that text type matters as well. Students in this study had the most trouble with compare/contrast text types. More importantly perhaps, was that students with learning disabilities had difficulty identifying text structure features, identifying relevant details, establishing connections among ideas, and using text feature strategies.

Individual factors and differences in learning continue to be important factors to consider when students learn online, particularly with complex science topics. Cognitive demands for learners increase as they engage in multiple documents in an online learning environment. For example, Coiro and Dobler (2007) found that skilled learners reading in an online environment required multiple levels of prior knowledge related to the topic, informational text structures, website structures, and web-based search engines. Skilled readers in this study also engaged in making forward inferences and SRL processes. Individual differences may increase with the complexity of learning and reading online and can also relate the types of continued instruction readers and learners need as they move into higher grade levels.

Considerations must be made in terms of a reader's ability to develop and acquire knowledge of text types and features when considering instruction (Englert & Hiebert, 1984). Teacher instruction plays a key role in exposing students to text types in a developmentally appropriate manner by providing direct instruction in discriminating training (e.g., providing two structure types for comparison; Roehling et al., 2017), providing graphic organizers or time to organize as aids to pool main ideas (Akhondi et al., 2011), and teaching text feature strategies to aid students with signaling words and text features (Meyer et al., 1980; Roehling et al., 2017; Wijekumar et al., 2012). The more knowledge students have of a particular text type, the more likely they are to engage in strategy use that promotes recall and retention of information from that text (Richgels et al., 1987). However, one cannot ignore text complexity when making these generalizations as compare/contrast or problem/solution text types can vary greatly based on complexity.

Exposure to text types through instruction can enhance comprehension in multiple ways. Instructional interventions on text types, where students are taught how to recognize different text types, facilitate learners' organization of material into summaries and generally improves reading comprehension assessment scores (Meyer et al., 2011; Roehling et al., 2017; Wijekumar et al., 2012). Readers are more likely to score higher on main idea or topic questions about their reading after exposure to text structure types (Kintsch & Yarbrough, 1982). Readers who have received direct instruction on text-structure interventions are able to recall clue words, use them in graphic organizers effectively to show relationships among ideas, and create summaries (Hall et al., 2005). Readers not only create their own organizational systems of material, but also gain insight into how authors organize ideas (Meyer & Ray, 2011). Exposing readers to this insight improves their organizational skills and contributes positively to the organization of their writing (Hebert et al., 2016; Meyer & Ray, 2011).

Web-based instructional tutoring studies offer additional information about the role of text type and strategy instruction on reading comprehension (e.g., Meyer et al., 2010; Wijekumar et al., 2012, 2014). Briefly, these studies showed that structure strategy instruction from a series of Internet trainings enhanced recall of important ideas. Factors influencing performance on assessment included elaborative versus simple feedback, modeling, and other instructional strategies provided by the intelligent tutoring systems. These studies involved assessment of the role of feedback and other variables wider than the scope of this review.

Researchers have studied common text types in traditional learning environments for decades. The role of text types in relation to learning and instruction is important to consider as students engage in more complex cognitive processing when learning online and when learning about science topics. The common text types from the literature are shown in Table 1.

Table 1

Common Text Types

Code	Name	Description
AR	Argumentation	Organization of main ideas into claims, supporting evidence, reasoning, and counterclaim
RF	Refutation	Texts with explicit statements alerting readers to misconceptions in prior knowledge
CC	Compare and Contrast	Organization of main ideas into similarities and differences
PS	Problem and solution	Organization of main ideas that present a problem and then a solution to the problem
DS	Description	Organization of ideas by attribute description
CE	Cause and effect	Organization of main ideas based on causation and produced effects

Text Structure Features

Text structure features are aspects of metatextual knowledge that include signal words and signaling devices. Signal words, such as italicized words within a text, cue a reader to text content. Other signal words, such "first" or "secondly" prompt a reader to organizational patterns purposefully used by authors to assist readers (Lemarié et al., 2008). Signaling devices are visually represented cues and phrases that prompt the reader to make connections when reading. Signaling devices include outlines, summaries, headings, bold words, color variation, and phrases such as "in conclusion" and "because of." Signal words and devices have different purposes when used within a text. These purposes are known as signal functions. These functions should be considered when reading online as they include alerting readers to organizational shifts in content, aiding in locating information and alerting readers to upcoming content.

Lemarié et al. (2008) presented multiple signaling functions and their connection to cognitive processing in SARA (i.e., Signaling as Relevant and Accessible), their theory of signaling. SARA is based on both text components and reader-based components. Text components (e.g., bold words or headings) signal the reader to available information. Signaling must also be relevant to the goals of the reader and available to readers' cognitive processing. Although not an exhaustive list, SARA offers six important dimensions of signaling that identify its function: demarcation, organization, labeling, identifying function, identifying topic, and emphasizing information. Demarcation includes physical boundaries on the page identified by headings or white space that visually inform the reader of an organizational shift. Organizational functions signal relationships between different parts of texts (e.g., overviews and summaries). Organizational functions are represented by the words used to signal relationships as opposed to the visual white space function of demarcation. Labeling functions as a way to index a topic and can include headings, outlines, preview sentences, and lists, using written language to inform the reader via introductory statements about the label attached. Words such as "introduction," "background," or "discussion" identify the function of a specific section of a text without identifying the content of the section. Identification of the topic is a more specific heading that states the upcoming content. Emphasizing information through the use of visual cues, such as italics, signals important elements of text.

Lemarié et al. (2008) addressed the importance of signaling from a processing perspective. There are many important cognitive processing connections between signaling and reading comprehension. The explicit structural boundaries of demarcation, or the spatial cues within texts, allow readers to locate specific information or content within a text search. The end of sections may also signal a reader to summarize content they have read or to prepare to shift to new content. Readers may evaluate and reflect upon their knowledge gains at the end of a section and go back to reread sections within the finished portion of text.

Organizational signals connect topics and themes within a text. Outlines, summaries, and topic headings draw attention to the main topics and themes within a text. Readers often have to infer meaning and make sense of a variety of information. Organizational signals can be important aids to readers as they process information. Cross-referencing devices, where the author refers to earlier parts of texts, are one example of explicit ways to draw connections for the reader. Labels such as headings also help readers make connections among topics. Signal words embedded in the text that use similar word choices as those in headings enable readers to better recall information (Lemarié et al., 2008).

When the function of the text is marked with an identifier, the reader with prior knowledge benefits from knowing what to expect within each section. Embedded signals within paragraphs that identify functions of sentences, such as "in conclusion" can alert readers to important elements of paragraphs. Although there is no definitive link at this time between identifying signal functions as a whole and cognitive effects, relationships between heading identification and cognitive processing have been explored. Learners who identified specific topics with headings showed aided processing, better outlining or highlighting of specific main ideas, and facilitated studying (Lemarié et al., 2008). Similarly, emphasizing words within texts through italics, for example, creates important indicators linked to better memory of these terms (Lemarié et al., 2008).

Lorch et al. (2012) found that explicit signaling through demarcation and preview sentences increased outlining performance and summarization of key ideas. Signaling features, such as summary and overview statements, and headings influenced recall of important information. The way in which students recall information closely relates to the organizational features found in texts (Lorch & Lorch, 1996). Interestingly, headings, summary, and overview statements also impact learners' recall. Text structure organization has been shown to aid recall (Lorch & Lorch, 1995). Therefore, signaling influences recall of author ideas in texts based on the ways in which authors present information.

A lack of signaling in texts places higher cognitive demands on readers who are trying to ascertain the text's organization and structure. Meyer and Poon (2001) used a structure strategy approach to help readers capture main ideas. The structure strategy allowed students to capture organized features of hierarchical texts and encode information, which has been found to improve both writing and recall of information (Meyer & Poon, 2001). Instruction in structure strategy offers readers training in identification of top-level, hierarchical text structure features. The learners read passages to gain overall main ideas and see how they are organized in the passage selection. Passages may include compare/contrast or other text types. Not only was there more recall on important information and the gist of the text with students who learned the structure strategy, but there were better writing outcomes. Also, readers are apt to transfer their knowledge of text features and signal words to other texts (Meyer & Poon, 2001).

Use of SARA offers insight into the ways in which signaling words have organizational and cognitive impacts on readers by expanding concepts related to metatextual knowledge. This theory is based in traditional print text, but structural and context cues have also been found to influence ways in which learners use inferential reasoning strategies when choosing what and where to read on the Internet (Coiro & Dobler, 2007). Structural features and signaling impact multiple areas of reading on the Internet.

Some aspects of research from reading multiple documents contribute to an understanding of how text structure influences reading online. Multiple documents are several separate texts written by different authors (Britt et al., 2014) that require complex cognitive processing. Learners who more often access prior knowledge of text structure features when reading multiple Internet documents are more efficient in their searches (Rouet & Coutelot, 2008). They spend less time searching multiple documents for the required information by using headings to locate information, for example. Familiarity of text structure features allows learners to locate information and answers to questions. When locating information within documents, Rouet and Coutelot (2008) found that as children developed, their use of top-down strategies (e.g., moving through a document from the top to the bottom using headings to predict content) increased their ability to locate information. Younger learners engaged in linear, traditional reading patterns from left to right, paragraph to paragraph. The students in Grade 7 used top-down search strategies most frequently and were considered the most efficient in their searches.

Learners who used textual cues and top-down search strategies showed a significantly lower relationship to locating information from those reading linearly. Therefore, if individuals want to locate specific information defined by the task instructions, for example, they may consider planning to read headings, use key words and other text features, and plan the time allocated to the task itself. Textual cues enhance reader ability to skim material and corroborate information. Skimming material that repeats information, for example, is more noticeable in older rather than younger students (Rouet & Coutelot, 2008).

Text features are also important to consider in relation to Internet searches. Internet searches require cognitive skills based on an understanding of the task and require learners to evaluate information for relevance to the task (Rouet et al., 2011). Experienced readers are more likely to delineate between relevant and irrelevant search terms across topics (Rouet et al., 2011). Younger students are generally more likely to use surface relevant cues that match words in the task definition more exactly, and they more frequently choose a larger number of irrelevant website titles from list menus (Rouet et al., 2011). Interestingly, Rouet and LeBigot (2007) found that with college-level students reading on the Internet, experience impacted use of text-level strategy use. Domain experts outperformed domain novices despite having similar prior knowledge. Domain experts' use of text structure features aided their comprehension of main ideas across sources and their knowledge of the content. Novices in the domain tended to use a more linear pattern of reading.

Rouet and LeBigot (2007) also suggested that text structure features of reading on the Internet impact writing. Learners who used text-structure features had higher specific recall and relevant accuracy on a written essay than novices. Novices spent more time reading in a linear fashion with specific attention to background information instead of spending longer amounts of time on more critical sections of the texts. Therefore, as individuals consider plans and goals for reading multiple sources, they may choose to enact strategies that use metatextual knowledge to increase their search efficiency and comprehension as a way to prepare for their time on task and recall information after the completion of the task (Rouet & LeBigot, 2007).

Signaling Research and Cognitive Processing Models

Aspects of metatextual knowledge, particularly signaling, signaling devices, and signaling functions act as built-in textual aids to direct readers to pay attention to certain words and organizational components of texts and to make connections between ideas (Lemarié et al., 2008; Lorch et al., 2012). The text components referred to in the SARA model specifically draw attention to available information. The reader then accesses prior knowledge and integrates this into an elaboration. Therefore, when forming a situation model (Kintsch, 1988) that uses signaling, readers generally access their prior metatextual knowledge and are internally cued to use key words to assist them in forming a mental model consistent with the task instructions. The integration of selected cues from the context of the task instructions and individualized inferences, attributions, and motivations that readers bring from the physical and surrounding environment cue the reader to access their prior knowledge on such things as the organizational features of texts. This helps them move towards their learning goals. If readers have metatextual knowledge and access it when they access their prior knowledge while reading, their situation model will be primed for higher levels of cognitive processing and ultimately, higher levels of comprehension.

Gaps in the Metatextual Knowledge Literature

Although extensive research exists on the effects of metatextual knowledge and text structure types and features in traditional print literacy (e.g., Akhondi et al., 2011; Dymock, 2005; Lorch & Lorch, 1995, 1996; Meyer et al., 2010; Meyer & Ray, 2011), few if any studies exist focusing on metatextual knowledge and text structure types and features both in isolation and in relation to other processes, such as SRL, in Internet reading environments. Examining the ways readers use metatextual knowledge in isolation could enhance understanding of the ways in which readers interact with particular contexts, or even topics, and how those interactions influence the ways in which readers construct knowledge using text features and strategies related to metatextual knowledge.

In addition, most of the research focused on written text and failed to account for the multimodal nature of the Internet in relation to text structure types. Signal words, for instance, are components of live video broadcasts of the news, TED talks, YouTube videos, podcasts, and even Khan Academy presentations. These are all common ways learners gain information online. Metatextual knowledge and text structure features must surely impact key ideas learners gain when using graphics, tables, and other forms of data presentation that differ both organizationally and structurally from one another and from written text.

When reading science documents, for example, learners should be able to interpret graphs, tables, charts, and other forms of data presentation (Britt et al., 2014; Goldman et al., 2016). In science, where the purpose of a document is often to provide evidence or reasoning to support a claim (Britt et al., 2014; Goldman et al., 2016), information in graphs, tables, and charts is often used to synthesize findings, can show causal relationships, and helps explain scientific phenomena. There was little, if any, research exploring how tables, graphs, or charts relate to a student's understanding of a scientific argument. These important components have been left out of the literature about online reading and learning. Research in this area can enhance how readers use information presented in charts to comprehend scientific data. Metatextual knowledge researchers have shown that signaling and signal functions such as labeling aid readers in capturing main ideas, summarizing, and taking notes on important information (Meyer & Poon, 2001). It would benefit learners if more research were done to determine if these skills transfer beyond written text to other modalities of the Internet.

Based on the fact that Internet readers generate their own reader pathways from using multiple sources to gather information (Castek & Coiro, 2015; Coiro & Dobler, 2007), their text types may include a combination of description and cause and effect, or argument and problem/solution. Further research could establish how various text types relate to strategy use. It is important to consider these issues and the impact they have on the skills and knowledge students need for successful Internet reading comprehension.

Metatextual Knowledge and Text Structure Features Enhancing Self-Regulated Learning

The first phase of Winne and Hadwin (1998) is task definition, where the learner identifies the meaning and purpose of the task. Text features such as signal words within the task definition can cue the reader to access prior knowledge and use important key words to identify the purpose (Lemarié et al., 2008). Task definition key or signal words may also cue a learner to identify the purpose of a task in more specific terms relative to text type, such as an argument (Jamieson-Noel, 2005). The purpose of the task could be to argue a point, compare and contrast an important issue, or describe historical moments of a period in time. In addition, key words from the task definition can assist learners in identifying important search terms that will aid in planning and task implementation. Prior metatextual knowledge, including how to selectively focus on key words, may allow learners to understand tasks more clearly, which has been shown to impact planning and enactment of the task (Butler & Cartier, 2004). It is worth considering that metatextual knowledge contributes to knowledge about how to approach a topic and how to more strongly interpret a task.

During planning and goal setting, text features such as italicized words from the task definition draw attention to the task purpose (Lemarié et al., 2008). Words that draw attention to the task purpose can assist learners in general goals: to gather general or background information on the topic, to search for claims and counterclaims for an argument (Jamieson-Noel, 2005), to summarize key causes and effects of an important event, or to simply ascertain the main ideas of an important historical event. By setting goals and creating plans, learners create a starting point for Internet searches and may gain insight into what particular documents to search for relevant to their task. SRL researchers have shown that learners who set goals for the purpose of mastering a concept, for example, engage in higher levels of particular strategies (Bernacki et al., 2012; Duffy & Azevedo, 2015), engage in higher levels of strategic processing (Zhou, 2013), and tend to perform better on academic tasks (Kitsantas et al., 2004 Zimmerman & Kitsantas, 2002).

Perhaps the largest role text features and types play in SRL is with strategy use during the enactment of the task. Text types and text feature strategies can play a strong role in monitoring and controlling reading performance. During a search, skimming the titles of search results can potentially aid learners in understanding the gist of the content associated with the topic, similar to how a table of contents allows readers to preview content by topic or chapter in a traditional print book. Reading the descriptions of the sites next to the title may reveal key words associated with the task that can aid readers in choosing which document better suits their needs and pertains to the previously set goals.

Prior to reading a document, learners can skim the document and look for headings, subsections, and signs of demarcation to determine relevance of content (Rouet et al., 2011). This can create more efficient searches as learners do not have to read line-by-line to determine connections to the task (Rouet & Coutelot, 2008). Inferring the adequacy of content has also been linked to learning gains. Students who more often expect content to meet their reading purposes and goals have shown higher levels of learning (Greene & Azevedo, 2007).

In addition, headings, subheadings, bold words, or key signal words can help readers capture main ideas, summarize, or know what to take down in notes (Meyer & Poon, 2001). Greene et al. (2008) showed that higher frequencies of strategy use and more engagement with effective strategies increased academic gain. SRL researchers, Bråten and Strømsø (2003), suggested that more frequent use of knowledge elaboration strategies (e.g., inferencing meaning from a text or elaborating on a portion of a text by accessing prior knowledge) predicts learning gains. Attention to key words from the text may allow students to access prior knowledge and increase likelihood of elaboration strategies.

Like identifying main ideas, summarizing, and potentially increasing the likelihood of knowledge elaboration strategies, key words may help readers make connections across documents more efficiently (Lorch & Lorch, 1995) by influencing reader patterns. If learners identify that a document is an argument, they may know to look for claims and counterclaims relevant to the task or determine to search for counterclaims if not present in the current document they are reading (Britt et al., 2014). Using text type and text feature strategies during reading can create more efficient Internet reading and strong organizational products that can result in better writing or reports on findings. Metatextual strategy use also enables better recall of material (Lorch & Lorch, 1995; Meyer et al., 1980).

During a learning task, as learners reflect upon their performance, adapt or change a strategy, or consider future performance adaptation, students may use metatextual knowledge and text features to check for understanding of content or judgements of learning to go back and locate more information on a topic to see if they understand the gist of the material (Kintsch, 1988), main ideas (Akhondi et al., 2011), and key purposes across texts. Demarcation (i.e., the spatial cues delineating a change in topic within a document [Lemarié et al., 2008]) offers a solid place for learners to stop the task and engage in reflection, choose to adapt, or continue with the task. Ideally, learners will use metatextual knowledge and text feature strategies throughout each phase of SRL to produce strong learning and written products. In the adaptation phase, learners may take key phrases from written feedback provided by teachers or reflection from their own understanding of the task and apply it to their learning on future tasks. During academic tasks, teacher feedback provides opportunities for students to improve their demonstration of learning.

Teachers are also instrumental in informing, instructing, and scaffolding students on ways to utilize text features and structural components of texts to enhance reading comprehension. How a student interprets task definitions and their level of knowledge and effective use of text types and text features depends on instruction. Direct, explicit instruction of text structure components has been shown to enhance student learning (Meyer et al., 2011; Roehling et al., 2017; Wijekumar et al., 2012). Instruction in metatextual knowledge, text structure types, and text structure features as it relates to each phase of SRL is one place to start.

Reading patterns of students as they plan, search, set goals, and read through documents can be optimized for efficiency (Rouet & Coutelot, 2008), consistency, and targeted focus as readers use metatextual knowledge to strategically limit intake of information, attach information to background knowledge schema, and elaborate on knowledge gained from a document (Lemarié et al., 2008). As students reflect on next steps in their process of gaining information from multiple sources, learners can change their key word search terms, change what they scan for within a document, make more connections during reading, and enhance comprehension. Integrating simple elements of text structure features and metatextual knowledge with prereading, during reading, and after-reading components of SRL makes room for learners to engage in organizational (Meyer & Poon, 2001), summative (Lorch et al., 2012; Meyer & Poon, 2001; Rouet & LeBigot, 2007), and connective strategy use (Meyer et al., 1980; Richgels et al., 1987) across multiple documents during reading on the Internet.

Coding for Metatextual Knowledge

This study used a secondary data set that has already been coded for SRL processes. The proposed coding scheme for the use of metatextual knowledge in relation to SRL processing for this study was an expansion of the coding scheme used in Greene et al. (2018). Greene et al.

adopted their coding scheme from previous research using TAPs on SRL processing (e.g., Azevedo & Cromley, 2004; Greene & Azevedo, 2009). The coding scheme initially included 35 codes that represented multiple aspects of processing: cognitive, metacognitive, motivational, and behavioral (Greene et al., 2011). This type of coding is one way to examine how quantitative data captures frequencies of codes in relation to learning outcomes (Greene et al., 2011). Greene et al. (2018) TAP data was coded into segments of utterances that indicated SRL processing. Breaking down verbalizations into segments was based on logical and codable units and sometimes followed natural pauses in speech (Greene et al., 2011). Codable units are the segments that contain the fewest number of words while still allowing for interpretation, even when the segment is removed from the context. The interpretation of the codable units indicates the cognitive, metacognitive, motivational, and behavioral processes of learners. The data was coded at a microlevel. For example, the codes SUM and INF were used to show a participant summarized or made an inference. Then the microlevel codes were aggregated at the macrolevel. Macrolevel codes included planning, monitoring, strategy use, and interest (Greene et al., 2014; Appendix A).

For this study, I created proposed microlevel codes from SRL processing microlevel codes (Greene et al., 2014) and aspects of metatextual knowledge. The microlevel codes referring to metatextual knowledge were pulled from signaling research (Akhondi et al., 2011; Jamieson-Noel, 2005; Lemarié et al., 2008; Lorch & Lorch, 1996; Meyer & Poon, 2001; Rouet & LeBigot, 2007) to indicate the use of metatextual knowledge on both a text and reader level. Text-level codes refer to text features such as bolding, italics, or use of headings specifically created by the author to cue a reader to content. The reader uses these cues to process information in a specific way (e.g., to summarize content). These codes are deeper strategy-level codes that refer to how the reader gathers the gist of information (Kintsch, 1998) about main ideas of sections or overall passages to aid recall (Meyer & Poon, 2001). I created multiple a priori text-level codes as a way to track deep-level engagement in metatextual strategy use. Reader-generated codes refer to instances where a reader is not visually cued from the text to pay attention to an aspect of the text by the author but does so anyway. Readers may cue themselves to a particular word as a way to inform their comprehension (Dymock, 2005) and make connections between ideas (Akhondi et al., 2011; Lemarié et al., 2008; Lorch et al., 2012). Researchers have determined that using multiple (i.e., surface-level and deeper level) strategies (Hagan et al., 2014) during online learning aids comprehension and relates to learning gains (Afflerbach & Cho, 2009; Cho, 2014). The coding scheme for the microlevel processes associated with signaling, their descriptions, and examples for text-based codes are presented in Table 2.

Table 2

Text-Based Micro-level Codes for Signaling

Code	Name	Description	Example
KWS	Key words to summarize information	Verbalizations that cue a reader to text content that aids in organizing and summarizing information. Key words may be marked by bold or italicized text.	Participant states “first,” “second,” plus reader-generated summary.
KWI	Key words to infer meaning	Verbalizations that cue a reader to text content meaning that requires prior knowledge. Key words may be marked by bold or italicized text.	Participant states the italicized or bold words or identifying markers such as the word “healthy” in the phrase “healthy adult.”
SWIT	Signal words to infer purpose of the task (Jamieson-Noel, 2005)	Verbalizations of key words and signal words from the task definition relevant to text type.	Participant refers to the word “argument” in the learning task and uses prior knowledge to infer the purpose of the task includes structural components of the argument text type.
HSM	Headings to summarize main ideas (Meyer & Poon, 2001)	Verbalizations marked by the use of bold text that denote an organizational shift in content to predict the topic appearing in a section that cues a reader to the main ideas of a text.	Participant uses content identifying headings to gather the gist of the content of the entire text during the enactment of the task.

Code	Name	Description	Example
HLI	Headings to locate information or answer questions (Rouet & Coutelot, 2008)	Verbalizations that denote a learner notices an organizational shift in content. Headings can be both content identifiers to predict the topic appearing in a section or can function to identify a specific section of a text without identifying upcoming content.	Participant says "I am going to the section on background to find the definition of fat-soluble."
HEAC	Headings to infer expectation of adequacy of content (Rouet et al., 2011)	Verbalizations indicating a participant is using bold text that denotes an organizational shift in content during previewing of a text that determines if the content of the text meets the goals or sub-goals of the task.	Participant reads a heading during previewing of the text and determines relevance of content to goals of the task and states that the content will or will not be useful.
SNT	Signaling words and devices that cue a learner to take notes (Meyer & Poon, 2001)	Key words, key phrases, and signaling devices such as headings within a text that prompt the reader to take notes.	Participant reads an italicized or bold word and writes down its definition.
MTS	Metatextual knowledge to synthesize information across multiple sources (Rouet & LeBigot, 2007)	Verbalizations that depict the use of signal words and devices to synthesize main ideas across multiple sources.	Participant states key words, headings, or other forms of metatextual knowledge to connect main ideas from varying sources.
TEAC	Titles to predict expectation of adequacy of content	Titles appearing at the top of each selected text are used to predict if the content of the text will meet the goals or sub-goals of the task.	After selection of a text, the learner reads the title of the text and infers/predicts content of the text, may also infer the adequacy of the content in terms of relevance to the task.

Reader-based codes are presented in Table 3. Microlevel codes were organized into a set of macrolevel codes related to SRL processing (Table 4). I created a priori reader-generated codes as a way to track the ways in which readers used language within the text to engage in deeper level strategy use within an online environment. For example, a participant reads the heading, “Special Nutrient Needs,” then uses the heading to predict that content following the heading will be adequate to meet the goal of the task. The verbalization was coded as a microlevel code, HEAC. The HEAC as a microlevel code was then organized as the macrolevel code MON, or metatextual knowledge for monitoring.

Table 3

Reader-Based Microcodes for Signaling

Code	Name	Description	Example
RKWS	Reader-generated key words for summarizing	Repeated utterance of a key word the reader uses to organize main ideas into a summary	Participant states they have seen the word “fat-soluble” twice and they summarize what the word means.
RKWI	Reader-generated key words for inferencing	Verbalizations where the reader is cued to access prior knowledge and create text content meaning	Participant states that vegetarians should take Vitamin D and infers that other people with potential vitamin deficiencies should also take it.

Table 4

Macrocodes for Metatextual Knowledge Use in Relation to Self-Regulated Learning

Code	**Name**	**Description**	**Example**
PLA	Metatextual knowledge for planning	The participant uses metatextual knowledge to implement a plan prior to or during the learning task.	The participant states they will scan the headings of a selected article for main ideas and general background information prior to reading a selected article.
MON	Metatextual knowledge as monitoring	The participant uses metatextual knowledge to monitor their reading.	The participant reads a heading or several headings and states that certain content (e.g., a section of text) will be adequate given the current goal.
STR	Metatextual knowledge as strategy use	The participant uses metatextual knowledge to implement a strategy.	The participant uses key words to draw a conclusion based on two or more pieces of information that were read, seen, or heard in the hypermedia environment in roughly the same time period.
INT	Metatextual knowledge indicating interest	The participant uses metatextual knowledge to indicate topic interest	The participant states that content is interesting or is not interesting after reading signal words, headings or other metatextual knowledge.

A set of secondary codes was established in this study based on text type literature (Alvermann & Hague, 1989; Britt et al., 2014; Meyer & Ray, 2011). Meyer and Ray (2011) identified six common text types. Alvermann and Hague (1989) and Britt et al. (2014) identified argumentation and refutation texts as common text types used in science literacy so these have been added to the proposed text type coding. The use of tables, charts, and graphs has also been included because of the multimodal nature of the Internet. The proposed text types listed in Table 5 were used to explore if the frequency of the use of SRL codes varied by specific text types.

Table 5

Secondary Codes for Text Types

Code	Name	Description	Common attributes of the text
AR	Argumentation	Organization of main ideas into claims, supporting evidence, reasoning, and counterclaim	Aspects of argumentation texts will often have to be inferred by the reader but may have statements cuing the reader to supporting evidence, reasoning, and counterclaims
RF	Refutation	Texts with explicit statements alerting readers to misconceptions in prior knowledge	Explicit statements within the text referring to a refutation of a common belief
CC	Compare and contrast	Organization of main ideas into similarities and differences	Use of terms "but," "alternatively," "however," to distinguish similarities from differences
PS	Problem and solution	Organization of main ideas that present a problem and then a solution to the problem	Problem, puzzle, solution, in response
DS	Description	Organization of main ideas by a description of attributes	Information organized by properties, attributes of, and characteristics
CE	Cause and effect	Organization of main ideas based on causation and produced effects	Cause, bring about, produce, explain, consequence
SE	Sequence	Organization of main ideas in relation to time	Use of terms "first", "secondly," "finally," "later," "recently"

Code	Name	Description	Common attributes of the text
VD	Video	Presentation of information by video—examples include a news broadcast, YouTube video	Signal words in videos will be spoken or emphasized via intonation in the speaker's voice or through graphic representations
TGC	Table, graphs, or charts	Presentation of information by tables, graphs, and charts or other graphics	Participant states they are looking at a table or graph

Conclusion

Strategies and skills play an important role in both traditional and Internet reading comprehension. As more learners in classrooms engage with material on the Internet, it is important to look closely at the differences between traditional print and Internet reading to best determine instructional that support student success during Internet reading. Fortunately, researchers of traditional literacy and SRL have captured key skills and strategies that benefit reader comprehension while reading on the Internet. However, one important area of research not extensively covered within SRL and online learning is metatextual knowledge and text structure features. The benefits of metatextual and text feature knowledge have been well-documented in traditional print literacy. They have also, albeit limitedly, appeared in multiple source use literature. Metatextual knowledge and text features improve learners' ability to organize and recall main ideas (Akhondi et al., 2011; Lemarié et al., 2008; Meyer & Poon, 2001) and aid in efficient searches of information (Rouet & Coutelot, 2008). Perhaps, more importantly, when included in SRL processes of task definition, planning, monitoring and control, and adaptation, metatextual knowledge should contribute extensively to these phases of reading on the Internet. This will enhance understanding and comprehension (Meyer et al., 2011;

Rouet & LeBigot, 2007; Wijekumar et al., 2012) and help students perform better when writing about a topic (Hebert et al., 2016; Meyer & Poon, 2001; Rouet & LeBigot, 2007).

Therefore, in this study, I explored the ways in which learners used metatextual knowledge as they made meaning from multiple science documents in an online reading environment. I examined the types of metatextual knowledge (e.g., bold words, headings, signal words) displayed by learners to see if metatextual knowledge use related to overall comprehension of science documents. I also analyzed learner verbalizations to determine whether the frequency of SRL processing differed across text types used during the learning task. The following research questions were addressed:

1. What metatextual knowledge do students use during a learning task on a complex science topic?
2. How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?
3. How does the frequency of self-regulated learning processing differ based on text types during an online learning task?

CHAPTER 3: METHODS

In this study, I used a preexisting dataset (Greene et al., 2018) to address the following research questions:

1. What metatextual knowledge do students use during a learning task on a complex science topic?
2. How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?
3. How does the frequency of self-regulated learning processing differ based on text types during an online learning task?

Participants

Fifty-three participants from a large southeastern university were recruited from multiple undergraduate courses in education for participation in a 90-min study about learning and beliefs about knowledge. Participants included 44 women and nine men. Fifty-one of the participants were undergraduates and two were graduate students. They represented a variety of majors. The mean participant age was 21.04 (*SD* = 4.00). The mean number of years in college for the participants was 2.98 (*SD* = 0.65). Participants who volunteered for the study received credit on an alternative assignment for their course.

Setting

For each participant, the study involved one 90-min laboratory session. Only the researcher and one participant were present in the laboratory during each session. The researcher sat outside the sightline of the participant to avoid bringing distractions into the environment

(Ericsson & Simon, 1993). The participants sat in front of a computer, were provided notepaper and pen, and had access to a timer. Participants were recorded by live video from behind and were audio recorded. Screen capture software was used to track participants' Internet exploration during the learning task.

Procedure

Prior to each session, my research colleague or I set up video and audio recording equipment, provided paper and pen, and set a timer to 30 min. Upon each participant's arrival in the lab, the researcher greeted them and instructed them to sit in front of the computer. Participants signed a consent form for inclusion in the study. Then, participants were given an eight-question multiple choice pretest constructed to test their existing vitamin knowledge. They had 20 min to complete the pretest. Participants were offered the opportunity to ask questions prior to starting the pretest and were encouraged to take their time and to perform at their best. Guessing on the pretest was discouraged so that my colleagues and I could accurately assess prior knowledge.

Next, we explained the TAP process. Participants were instructed to verbalize everything they were thinking and reading as they performed the task as if they were talking to themselves. Sample verbalizations were given, such as "That is interesting," or "I am going to click on this link." The researcher modeled how to think aloud on a website similar but unrelated to the website associated with the learning task. We gave the participant the opportunity to ask questions and then provided them with several minutes to practice thinking aloud on the website. When the participant demonstrated they could enact the TAP well, the practice session was ended.

Following the practice session, we introduced the learning task. We read aloud the task prompt to the participants. It stated:

> Imagine you are writing an argumentative essay (5 pages) for an undergraduate elective class in public health. Your assignment is: Is taking a daily vitamin beneficial for normal, healthy adults? To learn more and build your argument, you decide to consult sources on the Internet. You may choose any site to conduct your search. We have provided a list of sources you may choose to consider.

A printed copy of the learning task was posted in the participant's workspace for the participant to address as needed throughout the task. Daily vitamins were a justified topic for the learning task because they were a controversial everyday public health and science topic and it was likely participants had some prior knowledge it.

Each participant had 30 min to open a researcher-generated list of websites (Appendix B) and to access Internet resources of their choosing to learn about vitamins. This list of websites was generated by the researchers to provide opportunities for participants to engage in a variety of types of source information on a science topic (e.g., video, magazine articles, journal articles, news sources) and to promote participant source evaluation and selection processes. Websites were selected for their variety and depth of vitamin content. In addition, the websites represented a common level of reading difficulty to keep participants engaged in the learning task. A description of the suggested list of websites, their proposed text types, and distinguishing structural features is presented in Table 6. Two websites posted in the researcher-generated list of proposed sites were videos. However, all videos used by participants in this dataset were grouped together as one text type. Therefore, individual video descriptions are offered as samples of the variety of videos participants accessed

Table 6

Description of Website

Text type (Code)	Name of website	Website description
Video (VID)	Do vitamins really work?	News report that uses interview questions and answers to describe the role of vitamins in preventing disease, uses graphic images such as types of vitamins, presents examples of vitamins that may help people with deficiencies, includes several aspects of argumentation.
Video (VID)	Dr. Oz answers: What supplements do you take?	Video of television medical personality describing routine of vitamins and why they are important, compares gaining nutrients from foods to nutrients from vitamins, includes no graphic images, but sample bottles of vitamins are within sight.
Descriptive (DES)	Fortify your knowledge about vitamins (FDA)	Article that includes multiple bold topic headings to separate descriptive information and facts regarding reasons to take vitamins and safety considerations when purchasing vitamins; contains bullets, lists, quotes; contains embedded video.
Refutation (REF)	Vitamins: What to take, what to skip?	Health magazine and Health.com present a news-style article with title, subtitle, and bold headings identifying content, pictures, list of topics with descriptive information about vitamins and has organizational features at the bottom of each section. Presents argumentation with reasons, evidence, and some counterclaims.

Text type (Code)	Name of website	Website description
Problem/solution (PS)	More bad supplement news: Vitamin E may be risky for prostate	MSNBC news type article with title, embedded hyperlinks in different color, presents problem with vitamin E and offers solution: to get nutrients from food. Uses spatial demarcation.
Refutation (REF)	Multivitamins don't work	Blog post with embedded hyperlinks in blue, spatial demarcation, organizational features of comments from readers, argumentation with reasoning, evidence, counterclaim, and evidence for counterclaim.
Refutation (REF)	Vitamins and supplements: Do they work	Article from *U.S. News and World Report* about particular vitamins beneficial to individuals. Article includes hyperlinks, bold headings, italics, and graphic images. This article offers claim, reasons, evidence, counterclaims, and evidence for the counterclaims.
Argumentation (ARG)	Enough is enough: Stop wasting money on vitamins	This scholarly article offers organizational features that include abstract, conclusion paragraphs, and references. It is organized by spatial demarcation; has related articles with hyperlinks; and provides claim, reasons, and evidence.
Problem/solution (PS)	Skip the supplements	This article contains graphic images, quotes, and special demarcation. It presents a problem that vitamins are not regulated by the FDA. The solutions are for parents to sign a waiver during hospitalizations of children taking supplements and consumers to read labels of vitamins.

Text type (Code)	Name of website	Website description
Argumentation (ARG)	The case against multivitamins grows stronger	This article contains graphics, italics, quotes. It provides a claim, reasons, evidence, and a brief counterclaim.
N/A	Google.com	Additional search opportunity placed here for participants to click to engage in their own searches.

Note: FDA = Food and Drug Administration

During the task, participants were allowed to take notes. However, they were not allowed the use of other devices or learning aids during the task. Throughout the task, time prompts were given 20, 10, 5 and 2 min prior to completion of the 30 min session. If at any time during the task, the participant stopped thinking aloud for several continuous seconds, a prompt was given to "Say what you're thinking."

At the conclusion of 30 min, the timer was turned off and any open browsers were closed. If participants took notes, we removed them and placed them in a participant folder. Participants then had 20 min to complete the posttest. The posttest stated:

> Imagine you are writing an argumentative essay (5 pages) for an undergraduate elective class in public health. Your assignment is: Is taking a daily vitamin beneficial for normal, healthy adults? To learn more and build your argument, you decide to consult sources on the Internet. You may choose any site to conduct your search. We have provided a list of sources you may choose to consider.

Participants typed their posttest responses in a Microsoft Word document. None of the participants required more than the 20 min allotted for this task. Following the posttest, participants evaluated their Internet self-efficacy on a self-report measure. Then they filled out a demographic questionnaire. These final measures occurred at the end of the session to preclude any reactivity among the measures or performance on the task, posttest, and questionnaires. At the close of the session, participants were read to from a prescripted form that described the purpose of the study and how to reach the principal investigator with any problems or questions.

Additional procedures included the following: no notes could be used after the task was completed; the timer was visible; no questions could be answered during the task, and participants were told they and their screen movements would be video, audio, and screen recorded.

Data Sources

For the purposes of this study, the demographic questionnaire was used to examine any differences in behaviors between the undergraduate and graduate participants. Greene et al. (2018) found no statistically significant relationship between the internet self-efficacy measure and learning gains, therefore the former was not used in the current study.

Demographic questionnaire. A short document with questions related to age, gender, major, grade point average, and year in school (Appendix C).

Internet self-efficacy measure. A self-report questionnaire designed by the researcher was given to each participant after learning task completion. This questionnaire was designed for participants to evaluate their levels of self-efficacy while performing certain tasks on the Internet. This measure was not used for this study. (Appendix D).

Measures of knowledge and learning. The pretest (Appendix E) was an eight-question multiple choice test that measured participants' prior knowledge of vitamins. The multiple-choice question stems included questions such as: "Most people receive vitamin D from?" Five response choices gave options to the participants, such as "sunlight and dairy." Researchers independently scored the pretest. Each participant received one point per correct response.

The posttest (Appendix F) asked the participants to answer the following question in a typed, Microsoft Word document in 20 min:

> Imagine that you are taking a final exam in a public health elective course. Please respond to this question in the space below: If your friend, who is a normal healthy adult,

> asked you whether he or she should start taking a daily vitamin pill, what would tell this person to do and why? Be sure to include any relevant evidence that supports your advice.

Two researchers independently scored the posttest measure following a rubric centered on argumentation. Any disagreements on scoring were addressed via consultation. Participants earned two points for making a claim, (e.g., “Taking vitamins depends on the individual”). Claims were awarded two points whether they were correct or incorrect. Participants received one point per each reason or piece of evidence used to support that claim. Reasons in direct support of the claim included statements similar to the following: “Vegetarians should take vitamins to supplement missing protein from their diets.” In addition, evidence pertained to statements referencing specific sources such as “the Dr. Oz video” or “NPR stated . . .” A participant who cited a claim, two reasons to support the claim, and two pieces of evidence received a score of 6. Interrater scoring of the posttest measures was 92%.

Think-aloud verbalizations. Participants’ verbalizations were a primary data source used to code for metatextual knowledge use and SRL processing in this study. Details on think-aloud verbalizations was provided in the literature review

Coding

As mentioned in the literature review, I created text-based and reader-based signaling a priori microlevel codes based on metatextual knowledge to code verbalizations on the microlevel for Research Questions 1 and 2. In addition, secondary codes on text types were created and used to code the various text types participants encountered during the leaning task in combination with proposed SRL and codes. A portion of the coding scheme for Research Question 3 was based on the coding scheme initially developed by Azevedo and Cromley (2004) and iterated through multiple studies over the past decade (e.g., Azevedo, 2005; Azevedo, Guthrie, et al., 2004; Greene & Azevedo, 2007). Thirty-five SRL codes were used to develop understanding of the behaviors and processes related to knowledge acquisition and strategy use when reading about complex topics in hypermedia environments. Further coding adaptations were applied and validated in other studies (i.e., Greene et al., 2014, 2018). The coding scheme for this study combined codes from Greene et al. (2018) that had been validated with newly created metatextual codes. As mentioned in the literature review, I created macrolevel SRL codes based on the SRL literature (e.g., planning, strategy use, monitoring, and interest; Greene & Azevedo, 2009; Greene et al., 2013).

Coding took place as follows. First, using the list of researcher-generated websites provided to the participants, my cocoder and I coded the first two texts together to determine text type. Participants were able to view the list and click on each website or use Google to search for articles relevant to the task. Participants across the study accessed dummy sites most frequently. The remaining texts were coded for text type independently. My cocoder and I met to discuss the text-type codes until we reached agreement. Interrater reliability on the remaining text types was 67%. Admittedly, my cocoder and I experienced challenges during text type coding. We encountered texts that had some elements of several text types that we interpreted differently. For example, some factual information about vitamins could be interpreted as descriptive detail or evidence to support a claim. This was a new process for both of us and required cooperative analysis to identify the text types. We discussed all text types until we reached agreement on the coding.

Second, we coded the first 10 transcripts together for a priori metatextual microlevel codes. Each remaining transcript was then coded independently. We met to compare coded transcripts. We discussed any discrepancies until agreement. Initial interrater reliability on the a priori codes was 56%. The transcripts contained few a priori codes, therefore several were missed by one or both coders. Others were mistaken for codes that did not fit the research-based definitions. It was at this point I focused further attention on the discrepancies between the a priori codes and more specific behaviors participants used when they demonstrated metatextual knowledge. I discovered that, for example, participants noticed bold headings, but they did not utilize the bold headings to summarize or predict content. In response to the limited initial findings from the a priori metatextual codes in relation to learning gain, I created multiple post hoc microlevel metatextual codes. I created theory-driven microlevel metatextual codes based on the metatextual knowledge displayed by the participants. Both coders then coded each transcript a second time to identify the theory-driven microlevel metatextual codes. Interrater reliability for a priori and theory-driven microlevel metatextual post hoc codes for the transcripts was 79%.

Findings and rationale for each of the post hoc theory-driven microlevel metatextual codes are presented in Chapter 4. In addition, I aggregated theory-driven microlevel metatextual code data into metatextual macrolevel variables based on the metatextual literature (Lemarié et al., 2008). Theory-driven macrolevel variables included: signal words to emphasize information (e.g., quotes, italics, and reader-generated key words) and function of labeling. Functions of labeling included words that served as labels within a text such as bullets or lists. I included only bold headings as topic indicators in the bold variable. This remained a microlevel variable. I also created a macrolevel variable for the visual qualities of the text features that included graphics, tables, charts, graphs, videos, and hyperlinks as each of these represented information not generated directly from the immediate text and presented information in alternative forms. Therefore, the macrolevel post hoc codes were: MEMP, MLAB, and MVIS. BLD is a microlevel variable used on its own as a predictor. Table 7 contains a list of each theory-driven macrolevel metatextual variable and the included microlevel metatextual variables.

Table 7

Theory-Driven Macrolevel Metatextual Variables

Macrolevel variable	Microlevel variables included
MEMP	ITAL+RGKW+QUO
MLAB	ORG+BUL+LST+TISC+SISC+HLI+HEAC+HIC
MVIS	GRA+TGC+VID
BLD	BLD

Note: BLD is a theory-driven microlevel variable included in its own category.

In addition, I created data-driven, post hoc, macrolevel variables (Greene et al., 2018). The creation of data-driven, macrolevel variables involved correlating the frequency of each microlevel process with learning gain. Then, microlevel variables with sufficiently strong correlations with learning gain were aggregated. I determined correlation cut points at 0.1, 0.15 and 0.2. Variables with correlations of less than 0.1 were not included. Further, I differentiated between microlevel variables with a positive correlation with learning gain versus those with a negative correlation (Table 8). Only two microlevel variables had negative correlations meeting or exceeding my cutpoints and were included in the M15- macrolevel variable. Learning gain can be regressed on each of these macrolevel metatextual variables (e.g., metatextual macrolevel positive at .1, metatextual macrolevel positive at .15) to determine which individual variables, or which combinations, had the greatest predictive validity.

Table 8

Data-Driven Macrolevel Metatextual Variables

Macrolevel variable	Microlevel variables included
M10+	GRA + HLK + HEA + LST + BLD + BUL
M15+	HLK + HEA + LST + BLD + BUL
M20+	BLD
M15-	TGC + QUO

This two-tiered approach of using microlevel and macrolevel variables has been applied in previous SRL research to examine processes specific to the particular learning environment and individual learning differences (Greene & Azevedo, 2009; Greene et al., 2013) and to examine how the interactions of macrolevel processes of SRL interact with conditions of the learning environment across a learning task to influence learning (Greene et al., 2013).

For Research Question 3, I organized and separated each SRL code by the website the participant utilized. SRL codes during searching were separated from the SRL codes used during website viewing. I combined SRL codes used by the participants into each dummy site for this research question. For example, all SRL codes utilized during the NPR website, The Case Against Multivitamins Grows Stronger, were grouped together. SRL processing that took place outside of the dummy sites was not used for the purposes of this research question. Few participants used the same websites outside of those provided. Next, I created macrolevel variables for the following: PLA (i.e., all the microlevel SRL variables related to planning), STR (i.e., all the microlevel SRL variables related to strategy use), MON (i.e., all the microlevel variables related to monitoring, and INT (i.e., all the microlevel variables related to interest). These macrolevel variables were used based on previous research (Greene et al., 2018). These macrolevel variables allowed me to analyze how participant SRL processing might have differed across text types.

Statistical Analyses

For Research Question 1 (i.e., What metatextual knowledge do students use during a learning task on a complex science topic?), I ran initial descriptive statistics on metatextual microlevel codes, including mean, median, range, and frequencies of coding for Research Question 1. I examined outliers, skewness, and kurtosis.

For Research Question 2 (i.e., How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?), I regressed the posttest score on the pretest item score as in Greene et al. (2018) to determine any learning gain. The regression produced unstandardized residuals that represented variance not attributable to pretest knowledge differences. I used the unstandardized residual scores as the learning outcome variable and performed various kinds of regression using theory-driven and data-driven macros as independent variables and the learning gain as the dependent variable.

For Research Question 3 (i.e., How might the frequency of SRL processing differ by text types during an online learning task?), I analyzed the frequencies of macrolevel SRL processing per text type. I ran initial descriptive statistics and frequencies of SRL processes for each text type. To determine if a text type affected planning, strategy use, monitoring, and interest, I ran a repeated measures ANOVA using macrolevel SRL variables planning (PLA), strategy use (STR), monitoring (MON), and interest (INT) on argumentation, descriptive, refutation, problem/solution, and video text types. When running statistics for the repeated measures ANOVA, I had multiple cases where learners did not access a particular website. In addition, I had cases where participants accessed a website but did not engage in a particular microlevel process. I left this data blank, which created a listwise deletion when I performed the ANOVA. My sample size became too low for my analysis. Therefore, I went back and replaced the missing data with the value of zero for both instances where participants did not access a website and for participants who accessed a website but did not engage in any SRL processing. Replacing missing data with the value of zero allowed me to have a large enough sample size to run my analysis. See Table 9 for a crosswalk table of research questions, data sources, and data analyses.

Table 9

Crosswalk Table of Data Sources and Analyses

Research question	Data source	Data analyses
RQ1: What metatextual knowledge do students use during a learning task on a complex science topic?	• TAP data	• Initial descriptive statistics
RQ2: How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?	• Pretest score • Posttest score • TAP data	• Linear regression • Correlation of microlevel codes with learning gain variable • Regression of learning gain variable on macrolevel variable
RQ3: How does the frequency of self-regulated learning processing differ based on text types during an online learning task?	• TAP data • Text types	• Frequencies of SRL macrolevel processes • Repeated measures ANOVA

Note: RQ = research question; TAP = think-aloud protocols; SRL = self-regulated learning.

CHAPTER 4: RESULTS

The purpose of this study was to explore the ways in which learners use metatextual knowledge during a complex online science task in relation to achievement, and the ways in which different text types relate to the frequency of SRL processes. I used think-aloud protocol data to explore the use of signaling words (e.g., italics to cue the reader to important information) and signaling devices (e.g., bold words, headings, phrases such as "in conclusion" that represent organizational shifts in content). I also identified different text types learners used and the SRL processes from an existing dataset as learners engaged in an online science task in order to address the following research questions:

1. What metatextual knowledge do students use during a learning task on a complex science topic?
2. How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?
3. How does the frequency of self-regulated learning processing differ based on text types during an online learning task?

Table 10 identifies the theory-driven and data-driven microlevel and macrolevel metatextual and SRL variables for both a priori and post hoc analysis in this study.

Table 10

Theory-Driven and Data-Driven Microlevel and Macrolevel A Priori *and Post Hoc Codes*

Variable	Description	Example (code)	RQ analysis
Theory-driven a priori microlevel metatextual codes	Codes derived from the metatextual research to initially analyze the data for metatextual knowledge related to signaling functions and text types	Headings to infer the expectation of the adequacy of content. (HEAC) Argumentation text (ARG)	RQ 1 RQ 2
Theory-driven post hoc microlevel metatextual codes	Codes derived from the initial analysis of TAP data to effectively capture learner behavior and processes related to metatextual signaling functions	Participant states that they notice a bold heading (BLD)	RQ1 RQ2
Theory-driven post hoc macrolevel metatextual codes	All microlevel metatextual codes related to signaling functions combined into one macrolevel metatextual variable	All microlevel metatextual processes and behavior that relate to labeling functions including: ORG, BUL, LST, TISC, SISC, HLI, HEAC, HIC (MLAB)	RQ1 RQ2
Data-driven post hoc macrolevel metatextual codes	All microlevel post hoc variables with a positive correlation to learning gain of ≥ .1, ≥ .15, and ≥ .2. All microlevel post hoc variables with a negative correlation to learning gain of .15.	All correlations between the microlevel metatextual variables that have a positive correlation of ≥ .1 including: GRA+ HLK + HEA + LST + BLD + BUL (M10+)	RQ1 RQ2
Theory-driven a priori macrolevel SRL codes	Codes derived from SRL research to group all microlevel SRL processes related to planning, strategy use, monitoring, and interest	All microlevel SRL processes that display processes related to strategy use including: COIS, CV, DRAW, ECAQ, EM, INF, KE, MEM, PKA, RN, RR, SEARCH, SNIS, SKA, SUM, TN. (MSTR)	RQ3

Note: RQ = research question; TAP = think-aloud protocols; SRL = self-regulated learning.

Research Question 1

What metatextual knowledge do students use during a learning task on a complex science topic? The frequencies for a priori theory-driven microlevel metatextual codes are shown in Table 11. Nine a priori codes were generated from the research on metatextual knowledge. Prior to running statistics, I expected to find that participants at the undergraduate level would use metatextual knowledge as suggested in the literature. The research indicated that learners would engage in deeper level strategies related to metatextual knowledge that increase comprehension. I anticipated finding that learners engaged in deep strategies such as using metatextual knowledge to infer content of sections or using metatextual knowledge to signal important information. However, I found that participants only utilized three of the nine a priori microlevel metatextual knowledge codes. Thus, the frequency of theory-driven metatextual knowledge use was too small to analyze.

Table 11

Theory-Driven Microlevel A Priori Codes

Code	Name	Total *f*
KWS	Key words to summarize information	0
KWI	Key words to infer meaning	0
SWIT	Signal words to infer purpose of the task (Jamieson-Noel, 2005)	0
HSM	Headings to summarize main ideas (Meyer & Poon, 2001)	0
HLI	Headings to locate information or answer questions (Rouet & Coutelot, 2008)	5
HEAC	Headings to infer expectation of adequacy of content (Rouet et al., 2011)	6
SWTN	Signaling words and devices that cue a learner to take notes (Meyer & Poon, 2001)	0
MTS	Metatextual knowledge to synthesize information across multiple sources (Rouet & LeBigot, 2007)	0
TEAC	Titles on the website to predict expectation of adequacy of content	1

During the initial coding however, my co-coder and I noticed multiple ways that participants made comments related to metatextual knowledge that did not align with the a priori codes. We noticed learners pointed out bold headings or bulleted information or lists and commented on graphics, pictures, or charts they encountered during the learning task as they interacted with differing texts. I decided to create theory-driven post hoc microlevel metatextual codes related to these learner behaviors. Then, I created theory-driven macrolevel codes to capture multiple microlevel processes in each macrolevel variable. Table 12 provides descriptions of the theory-driven microlevel post hoc codes.

Table 12

Theory-Driven Microlevel Metatextual Post Hoc Codes

Code	Name	Description	Example
BLD	Notices bold headings	Verbalizations that depict learner notices a bold heading or indicates that they are skipping down to sections demarcated by bold words	"I'm just going to read the bold headings." "I'm skimming down and this just jumped out at me: fat-soluble vitamins."
BUL	Notices bullets	Verbalizations that indicate learner sees information presented in bullet form	"Here are some bullets, bulleted items."
GRA	Notices graphics	Verbalizations that learner notices a picture or graphic image on the website	"That picture is weird."
HIC	Headings to infer content	Verbalizations that a bold heading is used to infer content from the section of text directly after	Participant reads heading: "Practice safety with dietary supplements" then says this section looks like it is about precautions to take with vitamins.
HLK	Notices hyperlink	Verbalizations that indicate learner notices hyperlink within the website and clicks on it to seek out more information on the topic	"I'm going to click on this link to see what this has to say."
LST	Notices list	Verbalizations indicate learner notices information presented in list form	"Here's a list of vitamins."

Code	Name	Description	Example
ORG	Notices organization	Verbalizations that indicate organizational features of the website, such as an abstract or conclusion.	"I'm just going to read the abstract to get an idea of what this is about." "I'm just going to skip down to the bottom line to read the summary."
TISC	Titles to infer source content and/or the expectation of adequacy of content	Verbalizations that participant reads the title of the website while on the website and infers what the article will be about or whether or not the article content will be useful to the task	Participant reads title of the article then states: "This looks like it presents only one side."
TCG	Notices tables, graphs, or charts	Verbalizations that a table, graph, or chart is on the site and learner is looking at it for summarized information	"Here's a chart of all the vitamins and daily required doses."
QUO	Notices quotes	Verbalizations that information is quoted within the website from a particular source	"Then they quote what looks like an expert."
ITAL	Notices italics	Verbalizations to note that particular text is in italics	"So many italics."
VID	Notices video	Verbalizations indicate learner notices a video on the website and decides to watch it	"Here's another video by Dr. Oz. I'm going to see what this has to say."
SISC	Search results infer source content	Verbalizations indicate while using the search results, participant infers the source content and/or determines the source will be adequate or not adequate in relation to the task.	"This looks like it will present only one side of the picture." "This site looks good. I'm going to click on this link."

Descriptive statistics for a priori and post hoc metatextual knowledge microlevel variables are shown in Table 13. On average, participants noticed bold headings (BLD) most frequently, followed by using source information during searches to infer source content or whether or not source content would be adequate for the task (SISC). Participants inferred source content during searches (SISC) an average of 1.77 times. Over the course of 30 min, while utilizing multiple documents and engaging in multiple searches, learners inferred source content just below two times on average. Inferring source content is considered a valuable skill for online learning (Britt et al., 2014; Strømsø et al., 2013). Noticing organizational features such as abstracts and conclusions occurred with an average frequency of 1.32 per participant. It was not surprising but interesting to see how frequently learners commented on bold words or headings. Bold headings and words are visual indicators to signal important information or organizational shifts in content. This behavior indicated that learners were paying particular attention to structural areas that summarized key information for them. An abstract summarizes an entire article in a short passage. The conclusion summarizes the important or key points of the gist of the article. Both abstracts and conclusions are organizational features.

Table 13

Descriptive Statistics for Theory-Driven Microlevel Metatextual Variables

Variable	*M* (*SD*)	Range	Skewness (*SE*)	Kurtosis (*SE*)	Total *f*
ORG	1.320(1.988)	0–9	2.328(0.327)	5.838(0.644)	70
GRA	0.924(1.439)	0–5	1.666(0.327)	1.706(0.644)	49
HLK	0.434(0.721)	0–3	1.6809(0.327)	2.409(0.644)	23
TGC	0.250(0.738)	0–4	3.525(0.330)	13.728(0.650)	13
VID	0.320(0.547)	0–2	1.502(0.327)	1.424(0.644)	17
TISC	0.0943(0.354)	0–2	4.092(0.327)	17.648(0.644)	5
HEA	0.132(0.440)	0–2	3.488(0.327)	11.804(0.644)	7
HLI	0.2070409)	0–1	1.485(0.327)	0.211(0.644)	11
LST	0.245(0.515)	0–2	2.052(0.327)	3.560(0.644)	13
BLD	2.302(2.771)	0–12	1.670(0.327)	3.063(0.644)	122
RGK	0.057(0.233)	0–1	3.950(0.327)	14.137(0.644)	3
BUL	0.162(0.469)	0–2	2.873(0.327)	7.841(0.644)	9
HIC	0.019(0.137)	0–1	7.280(0.327)	53.00(0.644)	1
QUO	0.076(0.267)	0–4	3.309(0.327)	9.297(0.644)	4
ITAL	0.038(0.192)	0–2	4.994(0.327)	23.841(0.644)	2
SISC	1.773(1.705)	0–6	0.900(0.327)	.24(0.644)	94

In addition, several statistically significant correlations existed among multiple variables in this dataset, indicating relationships between the use of several microlevel processes. In addition, several theory-driven post hoc microlevel variables had a statistically significant relationship with learning gain (i.e., LGN; Table 14).

Table 14

Microlevel Metatextual Variable Correlations With Learning Gain

Code	LGN	ORG	GRA	HLK	TGC	VID	TISC	HEA	HLI	LST	BLD	RGK	BUL	HIC	QUO	ITAL	SISC
LGN	1	.089	.139	.194	−.193	.083	.082	.176	−.048	.183	.458**	.093	.116	−.068	−.167	−.021	.035
ORG	.089	1	.183	.196	−.033	−.043	−.044	.346*	.011	−.135	−.035	.002	−.101	−.093	−.155	.269	.363**
GRA	.139	.183	1	.218	−.188	−.018	−.061	−.014	.386**	.051	.493**	.299*	−.038	−.090	−.135	−.059	−.138
HLK	.194	.196	.218	1	.082	.128	.213	−.002	.080	.329*	.058	−.149	−.165	.304*	−.174	−.120	−.234
TGC	−.193	−.033	−.188	.082	1	−.109	−.093	−.105	−.113	.261	−.196	−.085	−.070	−.048	−.099	.068	.089
VID	.083	−.043	−.018	.128	−.109	1	.337*	−.099	.041	.125	.227	−.145	.308*	−.082	.095	.248	−.038
TISC	.082	−.044	−.061	.213	−.093	.337*	1	.042	−.138	.503**	−.010	−.066	−.098	−.037	−.077	−.053	.136
HEA	.176	.346*	−.014	−.002	−.105	−.099	.042	1	−.155	.194	.014	−.074	.168	−.042	−.087	−.060	.147
HLI	−.048	.011	.386**	.080	−.113	.041	−.138	−.155	1	−.064	.062	.277*	−.187	−.071	−.146	−.101	−.170
LST	.183	−.135	.051	.329*	.261	.125	.503**	.194	−.064	1	.217	.202	−.016	−.067	−.137	−.095	-.044
BLD	.458**	−.035	.493**	.058	−.196	.227	−.010	.014	.062	.217	1	.211	.344*	−.116	−.057	.267	−.161
RGK	.093	.002	.299*	−.149	−.085	−.145	−.066	−.074	.277*	.202	.211	1	−.089	−.034	−.070	−.049	.202
BUL	.116	−.101	−.038	−.165	−.070	.308*	−.098	.168	−.187	−.016	.344*	−.089	1	−.051	−.104	.353**	-.086
HIC	−.068	−.093	−.090	.304*	−.048	−.082	−.037	−.042	−.071	−.067	−.116	−.034	−.051	1	−.040	−.027	-.106
QUO	−.167	−.155	−.135	−.174	−.099	.095	−.077	−.087	−.146	−.137	−.057	−.070	−.104	−.040	1	−.057	−.048
ITAL	−.021	.269	−.059	−.120	.068	.248	−.053	−.060	−.101	−.095	.267	−.049	.353**	−.027	−.057	1	.242
SISC	.035	.363**	-.138	−.234	.089	-.038	.136	.147	−.170	−.044	−.161	.202	-.086	-.106	−.048	.242	1

**p* = .05, ***p* = .01

Research Question 2

How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic? Based on the correlations between the microlevel variables and the learning gain, only the use of bold headings was statistically significant to learning gain ($r[53] = 0.468$, $p = .01$). Also, I explored any differences between the use of metatextual knowledge and learning gains in undergraduates and graduate students. Two graduate students and 51 undergraduates participated in this study. Because of the low number of graduate students, analysis for this sample was too small, so I was unable to analyze any differences in the use of metatextual knowledge between graduate and undergraduate level in relation to learning.

Next, I ran descriptive statistics on the theory-driven post hoc macrolevel variables. MLAB (i.e., the macrolevel of labeling) had the highest mean frequency ($M = 2.58$, $SD[2.71]$). Next, I ran correlations of the theory-driven post hoc macrolevel variables and the learning gain (Table 15). I performed linear regression with the theory-driven macrolevel variables and the learning gain. (Table 16). I explored the regression further by adding the other post hoc macros. Only the use of bold headings was a statistically significant predictor of learning.

Table 15

Correlations of Metatextual Macrolevel Variables and Learning Gain

	Learning gain	MLAB	BLD	MEMP	MVIS
Learning gain	1	0.187	0.454**	0.120	0.061
MLAB	0.187	1	0.046	0.122	0.104
BLD	0.454**	0.046	1	0.097	0.439
MEMP	0.120	0.122	0.097	1	0.243
MVIS	0.061	0.104	0.439	0.243	1

***p was significant at .01*

Table 16

Regression Results Theory-Driven Metatextual Macrolevel Variables

Macrolevel variable	Microlevel variables included	ß weight	Significance
MEMP	ITAL+RGKW+QUO	ß = .260	.446
MLAB	ORG+BUL+LST+TISC+SISC+HLI+HEAC+HIC	ß = .121	.177
MVIS	GRA+TGC+VID	ß = -.263	.139
BLD	BLD	ß = .363	.000**

Note. BLD is a microlevel variable included on its own.
**p was significant at .05.

Next, I used correlation data from the micro-level variables to create data-driven macros. I combined all micro-level variables with positive correlations to the learning gain of 0.10 or greater into the macro M10+. I combined all positive correlations at 0.15 or greater into the macrolevel variable M15+ and negative correlations with the learning gain at .15 or greater into the macrolevel variable M15-. I combined all positive correlations with the learning gain of 0.20 and greater into M20+. I performed a stepwise regression to find the model that best related to learning. The regression results of data-driven macrolevel variables indicated that there was a statistically significant relationship between M15+ and learning gain, $R^2 = .250$, adjusted $R^2 =$

.235, $F(1, 50) = 16.683$, $p = .000$ (Table 17). Next, I ran a regression using M15+ and M15- to determine whether including M15- improved the model in any way. I cross-checked this model by reversing the order of these variables to allow the other variables to compete against each other to see which was the significant predictor. These series of regressions provided a more nuanced understanding and revealed only the macrolevel variable M15+ was statistically significantly related to learning gain.

Table 17

Regression Results Data-Driven Macrolevel Variables

Macrolevel variable and cutline	Microlevel variables included	ß	Significance
M10+ Correlation cutline positive .1	GRA+ HLK + HEA + LST + BLD + BUL	ß = .055	.862
M15+ Correlation cutline positive.15	HLK + HEA + LST + BLD + BUL	ß = .301	.000**
M2 Correlation cutline 0.20	BLD	ß = -.090	.792
M15- Correlation cutline negative .15	TGC + QUO	ß = -.168	.178

Note: BLD is a microlevel variable included as the only variable correlated at 0.20 or higher. Microlevel variables in M15+ included noticing hyperlinks, using headings to determine the expectation of the adequacy of content, and noticing lists, bold headings, and bullets.
***p* was significant at *.001.*

Research Question 3

How does the frequency of SRL processing differ based on text types during an online learning task? The following theory-driven, a priori macrolevel SRL codes were created: planning (PLAN), strategy use (STRAT), monitoring (MON), and interest (INT; Appendix A). Then I created a macrolevel SRL variable for each text type. For example, all of the strategy codes for descriptive texts were combined into the macrolevel variable SDES; all of the monitoring SRL microlevel codes for argumentative texts were combined into the macrolevel variable MARG. I ran initial descriptive statistics on each macrolevel variable (Table 18).

Table 18

Descriptive Statistics for each Macrolevel Text Type

Macrolevel variable	*M* (*SD*)	Range	Skewness (*SE*)	Kurtosis (*SE*)	Total *f*
PLANARG	.3585(.76194)	0–3	2.263 (.327)	4.569 (.644)	19
PLANDES	.4906(.84632)	0–3	1.613 (.327)	1.579 (.644)	26
PLANREF	.6981(.97241)	0–3	1.173 (.327)	.195 (.644)	37
PLANPS	.2642(.52444)	0–2	1.897 (.327)	2.893 (.644)	14
PLANVID	.1509(.41120)	0–2	2.827 (.327)	8.016 (.644)	8
STRATARG	4.1887(4.44651	0–17	1.178 (.327)	.736 (.644)	222
STRATDES	5.8302(6.96899)	0–27	1.402 (.327)	1.602 (.644)	309
STRATREF	8.2830(9.14704)	0–31	.790 (.327)	−.549 (.644)	439
STRATPS	3.3396(5.14760)	0–27	2.548 (.327)	8.218 (.644)	177
STRATVID	4.0943(5.03932)	0–23	1.701 (.327)	3.066 (.644)	217
MONARG	1.6038(1.82229)	0–9	1.610 (.327)	3.814 (.644)	85
MONDES	4.2264(4.99477)	0–19	1.298 (.327)	1.235 (.644)	224
MONREF	3.2830(4.36056)	0–18	1.486 (.327)	1.742 (.644)	174
MONPS	1.6415(2.51988)	0–12	2.109 (.327)	5.064 (.644)	87
MONVID	1.3019(1.42214)	0–4	.565 (.327)	−1.208 (.644)	69
INTARG	.6604(1.17577)	0–6	2.549 (.327)	8.036 (.644)	35
INTDES	.7547(1.83875)	0–10	3.328 (.327)	12.753 (.644)	40
INTREF	.9245(2.08335)	0–11	3.552 (.327)	13.876 (.644)	49
INTPS	1.0189(1.69264)	0–7	1.873 (.327)	3.146 (.644)	54
INTVID	.4151(.88652)	0–4	2.849 (.327)	8.884 (.644)	22

I conducted repeated-measures ANOVA tests to examine differences across text types (i.e., argumentative texts, descriptive texts, refutation texts, problem solution texts, and videos) on planning, strategy use, monitoring, and interest. Overall, results indicated statistically significant differences across text types on planning, strategy use, and monitoring, but no statistically significant differences across text type on interest (Table 19).

Table 19

One-Way Repeated Measures ANOVA Test Results

Variable	Value	*F*	Hypothesis *df*	Error *df*	*p* value	Partial eta squared
PLA	0.624	7.397	4	49	0.000	0.376
STR	0.767	3.728	4	49	0.010	0.233
MON	0.706	5.097	4	49	0.002	0.294
INT	0.837	2.394	4	49	0.063	0.163

I used paired samples *t* tests to conduct post hoc comparisons between text types by theory-driven a priori macrolevel code. Participants exhibited the most planning when utilizing refutation texts followed by the most planning taking place during descriptive texts. Learners planned the least on average when watching videos (Table 20). Paired samples *t* tests indicated significant differences in the relationship in planning between refutation texts and problem–solution text types (*M* = 0.434, *SD* = .141) and refutation and video presentation (*M* = .547, *SD* = .125; Table 21). Learners engaged in less frequent planning in problem/solution texts and videos than they did in refutation texts.

Table 20

Descriptive Statistics Planning and Text Type

Macrolevel Variable	*M*	*SD*	*N*
PLANARG	0.3595	0.7619	53
PLANDES	0.490	0.8463	53
PLANREF	0.698	0.9724	53
PLANPS	0.264	0.5244	53
PLANVID	0.151	0.4112	53

Table 21

Pairwise Comparisons Text Type and Planning

PLA (I)	PLA (J)	*M* difference (I–J)	*SE*	Significance [b]
ARG	DES	−.132	.159	1.000
	REF	−.340	.177	.599
	PS	.094	.127	1.000
	VID	.208	.109	.623
DES	REF	−.208	.171	1.000
	PS	.226	.110	.444
	VID	.340	.126	.095
REF	PS	.434*	.141	.034
	VID	.547*	.125	.001
PS	VID	.113	.088	1.000

Note: Based on estimated marginal means.
[b] Adjustment for multiple comparisons: Bonferroni.
*The mean difference was significant at $p < .05$.

There is a statistically significant difference between text type and strategy use amongst different text types. Wilks's lambda = 0.767, $F(4,49) = 3.728$, $p = 0.010$. Descriptive statistics for strategy use across text types are in Table 22. Paired samples *t* tests indicated significant differences in strategy use between refutation and argumentation texts ($M = 4.094$, $SD = 1.345$, $p = 0.037$), refutation and problem solution texts ($M = 4.943$, $SD = 1.432$, $p = .011$), and refutation and videos ($M = 4.189$, $SD = 1.270$, $p = .018$; Table 23).

Table 22

Descriptive Statistics Strategy Use

Macrolevel Variable	*M*	*SD*	*N*
STRATARG	4.1887	4.44651	53
STRATDES	5.8302	6.96899	53
STRATREF	8.2830	9.14704	53
STRATPS	3.3396	5.14760	53
STRATVID	4.0943	5.03932	53

Table 23

Paired Comparisons Strategy Use

STRAT (I)	STRAT (J)	*M* Difference (I–J)	*SE*	Significance [b]	95% *CI* for difference [b]	
					Lower bound	Upper bound
ARG	DES	−1.642	1.156	1.000	−5.031	1.748
	REF	−4.094*	1.345	.037	−8.038	−.151
	PS	.849	.892	1.000	−1.766	3.464
	VID	.094	.822	1.000	−2.314	2.503
DES	REF	−2.453	1.451	.970	−6.708	1.802
	PS	2.491	1.116	.299	−.781	5.762
	VID	1.736	1.069	1.000	−1.400	4.871
REF	PS	4.943*	1.432	.011	.745	9.141
	VID	4.189*	1.270	.018	.467	7.911
PS	VID	−.755	1.015	1.000	−3.730	2.220

Note: Based on estimated marginal means.
[b] Adjustment for multiple comparisons: Bonferroni.
*The mean difference is significant at the $p > .05$ level.

There is a statistically significant difference of text type on monitoring and different text types. Wilks's lambda = 0.706, $F(4,49) = 5.097$, $p = 0.002$. Learners reading descriptive text types monitored their learning most frequently, followed by refutation texts. Learners watching videos monitored their learning the least (Table 24). Paired samples *t* tests indicated significant differences in monitoring across text types. Descriptive and argumentation text types ($M = 2.623$, $SD = 0.715$, $p = .006$), descriptive and problem solution text types ($M = 2.585$, $SD = .645$, $p = .002$), and descriptive and videos ($M = 2.925$, $SD = 0.703$, $p = .001$) all showed significant differences in monitoring (Table 25).

Table 24

Descriptive Statistics Monitoring

Macrolevel Variable	*M*	*SD*	*N*
MONARG	1.6038	1.82229	53
MONDES	4.2264	4.99477	53
MONREF	3.2830	4.36056	53
MONPS	1.6415	2.51988	53
MONVID	1.3019	1.42214	53

Table 25

Paired Comparisons Monitoring

MON (I)	MON (J)	*M* difference (I–J)	*SE*	Significance [b]
ARG	DES	−2.623*	.715	.006
	REF	−1.679	.654	.131
	PS	−.038	.412	1.000
	VID	.302	.301	1.000
DES	REF	.943	.695	1.000
	PS	2.585*	.645	.002
	VID	2.925*	.703	.001
REF	PS	1.642	.610	.096
	VID	1.981*	.627	.026
PS	VID	.340	.411	1.000

Note: Based on estimated marginal means.
[b] Adjustment for multiple comparisons: Bonferroni.
* The mean difference was significant at $p < .05$.

Overall, there was no significant effect of text type on interest across text types. Wilks's lambda = 0.837, $F(4,49) = 2.394$, $p = 0.063$ (Table 26). However, within pairs comparisons revealed significant differences in text type on interest between problem–solution texts and videos ($M = 0.604$, $SD = 0.197$, $p = 0.034$; Table 27).

Table 26

Descriptive Statistics Interest

Macrolevel Variable	*M*	*SD*	*N*
INTARG	.6604	1.17577	53
INTDES	.7547	1.83875	53
INTREF	.9245	2.08335	53
INTPS	1.0189	1.69264	53
INTVID	.4151	.88652	53

Table 27

Paired Comparisons Interest

INT (I)	INT (J)	*M* Difference (I–J)	*SE*	Significance [b]
ARG	DES	−.094	.284	1.000
	REF	−.264	.327	1.000
	PS	−.358	.248	1.000
	VID	.245	.210	1.000
DES	REF	−.170	.309	1.000
	PS	−.264	.300	1.000
	VID	.340	.267	1.000
REF	PS	−.094	.226	1.000
	VID	.509	.251	.473
PS	VID	.604*	.197	.034

Note: Based on estimated marginal means.
[b] Adjustment for multiple comparisons: Bonferroni.
* The mean difference was significant at $p < .05$.

Findings from this study revealed that learners predominantly displayed metatextual knowledge by acknowledging the presence of metatextual features, such as bold headings, lists, or graphics, but failed to enact metatextual knowledge at deeper levels, such as summarizing, inferencing, or locating information. The use of bold headings in this study was a statistically significant predictor of learning. However, when using the two-tiered approach with macrolevel variables, the macrolevel variable with a positive correlation cutpoint at .15+ showed a statistically significant relationship with learning. The macrolevel variable at .15+ had several variables where learners noticed metatextual variables such as bold headings or bullets, for example, but also used headings to determine the expectation of content adequacy. When looking at the relationship between text types and SRL macrolevel processes, refutation texts had the highest levels of frequency of planning, strategy use, and monitoring when compared to argumentation, descriptive, and problem/solution texts. Overall, there was a statistically significant relationship between refutation text types and planning, strategy use, and monitoring but no statistically significant relationship between text types and interest.

CHAPTER 5: DISCUSSION

Reading science documents in online learning environments requires learners to engage in complex thinking and processing behaviors. Argumentation documents in science, for example, are structured to address how something is known by presenting a claim, explaining the claim through reasoning and evidence, and presenting and refuting a counterclaim (Britt et al., 2014; Goldman et al., 2016; Henderson et al., 2018). Refutation texts are purposefully structured to state common beliefs that promote changes to misconceptions learners have about science topics (Meyer & Poon, 2001). The purposeful structured elements of different texts in traditional reading contexts are often utilized to enhance recall (Hall et al., 2005; Richgels et al.,1987), and choices about the organization of main ideas are often made to increase understanding of the gist of reading material (Akhondi et al., 2011; Kintsch, 1988; Lemarié et al., 2008; Meyer et al., 2011). Researchers have identified that as students get older, they are exposed to more difficult types of texts (Englert & Hiebert, 1984; Richgels et al., 1987). Also, researchers have explored the role of metatextual knowledge in online environments and suggested that skilled online learners use metatextual knowledge to increase efficiency when locating information and answering questions online (Rouet & Coutelot, 2008) and navigate different website structures (Coiro, 2011b). The behaviors of successful online learners in combination with the variety of ways metatextual knowledge enhances learning in traditional print literacy indicate a need for further research on metatextual knowledge in online environments.

The use of online environments, where learners access multiple documents during one experience, exposes learners to multiple texts with potentially varied text structure, organizational features, and signaling devices. Several researchers have shown that prior knowledge of text structure features, the presence of SRL skills (Coiro, 2011a), and metatextual strategy use (e.g., using headings to locate information; Rouet & Coutelot, 2008) aid comprehension and recall. However, few researchers have explored specific metatextual strategies in relation to learning. Nor have they explored the relationship of text types to SRL processing. Very few researchers have addressed metatextual knowledge in online learning environments at the college level. Therefore, the purpose of this study was to explore the use of metatextual knowledge during an online learning task of a complex science topic in order to contribute to greater understanding of the ways in which learners use metatextual knowledge in online learning environments, how the use of metatextual knowledge relates to achievement, and the role of text types in SRL processes. I explored these topics with an emphasis on the following research questions:

1. What metatextual knowledge do students use during a learning task on a complex science topic?
2. How does the use of metatextual knowledge relate to achievement in an online learning task of a complex science topic?
3. How does the frequency of self-regulated learning processing differ based on text types during an online learning task?

Research Question 1

Lemarié and colleagues (2008) created the SARA model to identify specific structural and organizational functions within traditional texts (e.g., signaling and using key words to summarize information) that have been shown to relate to higher level strategy use or deeper conceptual knowledge (Meyer & Poon, 2001). Of the nine theory-driven a priori microlevel metatextual codes, participants engaged in these processes only three times in the entire dataset. Participants noticed headings to locate information (e.g., HLI), used headings to determine the expectation of the adequacy of content (e.g., HEAC), and used the titles of the websites to determine expectations about the adequacy of content once participants were on the website (e.g., TEAC). The failure of participants to engage in sufficiently frequency use of a priori theory-driven codes made it impossible to continue with the experiment. The amount of data was too small. Therefore, I created post hoc theory-driven microlevel codes reflecting how learners actually engaged in a variety of metatextual knowledge processes that related to the structural and organizational functions of texts. The metatextual knowledge indicators in this exploratory study aligned more closely with the structural and functional recognition of metatextual knowledge (Lemarié et al., 2008) as opposed to deeper level thinking and processing as highlighted in previous research on metatextual knowledge (Akhondi et al., 2011; Jamieson-Noel, 2005; Lemarié et al., 2008; Lorch & Lorch, 1996; Meyer & Poon, 2001; Rouet & LeBigot, 2007). There are several explanations for the lack of participant engagement in behaviors and processes related to the theory-driven a priori metatextual codes.

One potential explanation for the lack of participant engagement in behaviors related to the theory-driven a priori processes can be attributed to the multimodal nature of the websites. Learners can take multiple paths to choose content, move through content, or switch from reading to watching a video or exploring a hyperlink for more information. For example, on the FDA website used in this study, readers had the choice of reading text directly on the website, clicking on a video of the same information presented verbally, or clicking on various hyperlinks within the web environment. On the scholarly opinion article website, participants had access to articles with hyperlinks that related to the article itself, hyperlinks to related topics, and hyperlinks to the articles in the reference section. Learners had to make multiple decisions when they engaged with these. As learners read and comprehend, their decisions may include whether to pursue other links to gain more information. They may infer content of hyperlinks and its relevance to the task. They may engage in source evaluation of the link. These different levels of cognitive processing require increased levels of active strategy use, monitoring of strategies, and changing strategy use to optimize learning (Pressley, 1995). This could cause some students to feel overwhelmed, lose focus, or become disorientated (Cho, 2014). In addition, learning in online environments requires increased levels of SRL and metacognition (Azevedo & Cromley, 2004; Azevedo, Cromley, et al., 2004; Azevedo, Guthrie, et al., 2004). A likely explanation for more superficial levels of metatextual knowledge displayed is that participants were in fact engaging in deeper level thinking and strategy use but were not using metatextual knowledge to aid them in these processes because of the complexity associated with the online learning environment and the decision making required to navigate through the task.

During the complex science task, participants accessed multiple sources of information, were free to choose their own path, and engaged with multiple texts ranging in complexity by structure and genre. Participants engaged in complex decision making to choose multiple sources relevant to the task and navigate through a variety of information sources. The ways in which information was disseminated differed organizationally, structurally, and functionally. Differences between organizational and structural features on each website within the learning task likely contributed to complex navigation through the learning task as well. Multiple sites provided organizational shifts through bold section or topic headings, lists of important content highlighted in boxes to the side of the main content, or had neither of these. Participants had only 30 min to complete the learning task. Bråten and Strømsø (2003) tracked the progression of student learners as they engaged in reading multiple documents and found that learner strategies changed from simple strategy use (e.g., memorization of content) during the beginning of their learning to deeper strategy use (e.g., elaboration) as the learners progressed and spent more time within the documents. Therefore, many participants in the current study may have chosen to comprehend information or finish reading content within the allotted time for the task. They possibly recognized metatextual knowledge on a simplified level but did not use it to engage in deeper strategic reading because of the nature of the website, the complexity of the science texts, or simply because they were working within the confines of the time constraint.

However, the fact that participants failed to engage in deeper level use of metatextual knowledge, such as using headings to infer content, was concerning, especially considering the participants included undergraduate- and graduate-level students. The role of metatextual knowledge within traditional literacy suggests that students are exposed to structural and organizational features of texts as early as third grade (NGSS Lead States, 2013) with extensive opportunities to practice and engage with texts rich in metatextual knowledge through grade levels (NGSS Lead States, 2013). Consequently, it was surprising to see this failure in learners at the undergraduate and graduate level.

Research Question 2

Overall, regression analysis results from Research Question 2 indicated learners who noticed bold headings showed significant learning gains. In this study, many to most of the bold headings contained factual information about vitamins within the content subsections. The learning gain could be attributed to the factual knowledge obtained through the use of these headings and subsections. Learners who use bold headings that identity topics, for example, may mentally prepare to make cognitive shifts prior to engaging in detailed content (Lemarié et al., 2008). In this study, learners noticed bold headings in multiple and varied ways. Many participants scanned the documents prior to deep engagement and simply read the bold headings.

This behavior could indicate that learners got an overall impression of the gist of the article prior to deeper engagement. Other participants skipped down to a bold heading after reading a particular passage and used bold headings as organizational shifts in their reading or to potentially shift topics due to time. This behavior is consistent with literature that identifies bold headings as markers for organizational shifts in content (Lemarié et al., 2008). Still others read documents top to bottom and merely mentioned that they noticed the headings were bold. When using a multitiered approach to Research Question 2 through the use of theory-driven macrolevel variables, the overall model showed a statistically significant relationship between bold headings and learning. This confirmed the power of noticing bold headings within the context of this learning task.

When exploring data-driven macrolevel variables with correlation cutpoints in relation to learning gain, the macrolevel variable positively correlated at .15 showed a significant relationship to learning. This macrolevel variable consisted of the following microlevel metatextual variables: noticing hyperlinks (e.g., HLK), using headings to determine the expectation of the adequacy of content (e.g., HEAC), noticing lists (e.g., LST), and noticing bold headings (e.g., BLD). These microlevel variables represent a combination of surface-level ways participants noticed structural and functional elements of their texts as well as one deeper level strategy (e.g., HEAC) generated from theory where participants used metatextual knowledge to predict content. These findings align with strategy research and metatextual knowledge research from traditional literacy. Learners who know and use structural aspects of reading, for example, have shown increased levels of comprehension (Akhondi et al., 2011; Dymock, 2005; Goldman & Rakestraw, 2000) and have shown increased comprehension of the gist of the material (Akhondi et al., 2011; Kintsch, 1988). Headings are often bold words and function as labels to identify topics or represent organizational shifts in topics within a text (Lemarié et al., 2008). Headings that function as topic identifiers signify upcoming content by briefly presenting main ideas (Lemarié et al., 2008). For example, a learner who previews a text and reads only the headings would be able to infer the content of the sections following each heading. When learners utilize headings in this manner, they engage in deeper use of metatextual knowledge by making connections across main ideas. Learners can then make informed choices about whether or not the inferred content can adequately meet the needs of the task. Therefore, headings to infer the expectation of adequacy of content (e.g., HEAC) are a deeper level strategy. Findings related to HEAC in this study align with the research on labeling functions, organizational shifts, and bold headings. When combined with the other microlevel variables in M15+, the metatextual components in the macrolevel variable that showed a relationship to learning contained both structural and functional aspects of metatextual knowledge. The results from Research Question 2 align with the research on how structural and functional aspects of metatextual knowledge relate to cognitive processing associated with learning (Lemarié et al., 2008).

It is understandable however, that some online learners failed to consider metatextual knowledge at all or failed to use metatextual knowledge on a deeper level. Some learners may have failed to recognize the utility of metatextual knowledge as a memory aid or memory enhancer, or simply had no skills or prior knowledge associated with metatextual knowledge. They may have adopted strategies that were finer grained (e.g., inferencing, knowledge elaboration, or prior knowledge activation) and immersed within the content as opposed to those focused on the bigger picture such as summarizing key ideas or getting the gist of the entire picture. This is not surprising considering many students in the real-world struggle with summarizing key content across domains, fail to integrate strategies to aid this process (Pressley et al., 1992; Randi et al., 2005), and can fail to activate prior knowledge (Randi et al., 2005). The complexity of online learning environments calls for a combination of skills from multiple areas of research to include new skills and processes borrowed from educational psychology related to source evaluation, skills integrated from New Literacies (Leu et al., 2013; 2015), and skills from traditional reading comprehension, including metatextual knowledge.

In addition, there are some methodological concerns that relate to why metatextual knowledge use did not relate to learning gains. The coding practice in the current study remained low inference, relying on utterances and verbalization to ascertain metatextual use. It is possible that participants were utilizing metatextual knowledge more than indicated in the TAPs. The scrolling and skimming behavior captured by the screen capture software did not track where exactly within a line of text participants looked but focused on the general area where they were reading on the screen. Participant behavior during online engagement may have become so highly automatized that learners failed to verbalize when they glanced at a picture, noticed a hyperlink, or organizationally shifted from reading content and skipping material down to a bold holding, as can often happen within a website that has text, graphics, hyperlinks, and suggested articles or advertisements on the side of the screen. One way to address this is to use eye tracking software (Taub & Azevedo, 2016). Eye tracking software shows where learners look on the website, when their eyes are drawn to graphics or articles posted on the sidebar, and does not rely on verbalizations to capture the data. As utilized in multiple studies throughout SRL research, gaze behaviors have been explored in relation to prior knowledge (Taub & Azevedo, 2016) and behavioral processing (Trevors et al., 2016), and they continue to present benefits and methodological challenges for SRL data analysis (Azevedo & Gaševic, 2019). In this study, it is possible think-aloud protocols did not actually capture all of the participants' thoughts as they engaged in the learning task. Participants may have engaged in more nuanced, quick glances to parts of the website and therefore may have higher numbers of frequency of the microlevel metatextual knowledge than captured by the TAPs. In addition, participants noticed multiple aspects of metatextual knowledge that align with past research, but many did not relate to learning directly when combined into macrolevel variables. However, metatextual knowledge also relates to text types. Research Question 3 explores the relationship between SRL and text types more fully.

Researchers in traditional literacy have shown that after exposure to instruction on text structure types, readers have shown increased scores on topic and main idea questions (Kintsch & Yarbrough, 1982); therefore, knowledge of text types relates to the ways in which processing occurs. Text types and their relationship to SRL processing were explored in Research Question 3: How does the frequency of SRL processing differ based on text types during an online learning task? Results from this study indicated that on average, learners engaged in planning, strategy use, and monitoring at the highest levels of frequency when reading refutation texts. Task complexity has been shown to impact planning and implementation phases of learning (Butler & Cartier, 2004). More complex tasks require more effort during planning and implementation than prior to starting a task (Thiede & Dunlowsky, 1999). Despite very little research on planning in the SRL literature, learners engaging in complex tasks have been shown to spend more time planning (Bromme et al., 2010). Learners in this study may have experienced more task and text complexity when engaging with refutation texts. Refutation texts include claims, counter claims, and evidence to support these claims in order to dismantle misconceptions of a topic and challenge readers' prior knowledge on a topic (Alvermann & Hague, 1989; Chambliss, 2002). The more knowledge learners have about text types and their structural components, the more likely they are to engage in strategy use that leads to retention (Richgels et al., 1987).

Text complexity associated with refutation science writing in this study required learners to engage in higher levels of strategy use and high levels of metacognitive monitoring and control. Learners engaged in strategy use during reading refutation texts almost twice as often as when reading argumentation, descriptive, or problem/solution texts. Learners engaged in higher frequencies of strategy use within refutation texts, which contain claims, evidence, and counter claims. These findings indicated that higher levels of strategy use were utilized and perhaps required of learners as they read refutation texts. SRL researchers have shown that learners who use elaboration strategies, such as knowledge elaboration and inferencing, have increased levels of understanding of content (Greene & Azevedo, 2007). Learners who integrate deeper and more frequent strategy use have shown increased levels of comprehension (Hagen et al., 2014). In addition, learners with high levels of prior knowledge of strategies have been shown to engage in more use of SRL strategies than those with low prior knowledge of strategies (Taub et al., 2014). Learners using refutation texts in this study were on average more likely to engage in monitoring behaviors than learners reading argumentative or problem/solution texts. Therefore, it is possible that the learners' increased attention on SRL processes, particularly planning, strategy use, and monitoring, within refutation texts created conditions requiring different levels of skill complexity and their attention was focused on comprehension of material.

In addition, intertextual strategies are important when reading across documents (Afflerbach & Cho, 2009; Cho, 2013, 2014). Skilled and more successful readers who use complex intertextual strategies are able to predict content in more forward-thinking ways (Coiro & Dobler, 2007). The learning task in this study required multiple intertextual strategies across varying text types that created a complex learning environment for participants. Learners' use of different SRL processing, strategy use, and monitoring and control across text types aligns with SRL research that has demonstrated the importance of individual characteristics as well as the contextual elements of the task, including the text and the structural features embedded in text structures.

Potential Limitations

The study used a secondary data set that was designed to explore SRL and its relation to knowledge gains in an academic environment. Although this data set was rich in its affordances of participants' thoughts as they learned, the study was not targeted specifically on metatextual knowledge. Although this method allowed for insight into the unprompted ways in which learners naturally utilize metatextual knowledge within a structured learning environment, the task design allowed little room for extensive focus and exploration. If this study had specifically been designed with metatextual knowledge as a framework, I would have incorporated websites with both similar levels of metatextual knowledge present and a large number of varied structural and functional components of metatextual knowledge. Within the task definition, learners could have been instructed to pay attention to particular text types, argumentation texts, or text features. Learners could also have been pretested on their metatextual knowledge or have engaged in a brief supplemental interview after the learning task to discuss their awareness of their own metatextual knowledge. This approach would have more specifically targeted metatextual knowledge. However, with the current design of the learning task, any use of metatextual knowledge captured in the TAP data added insight to the natural ways that learners accessed prior knowledge on test types and text features.

Methodologically, TAP data fails to capture gaze behavior and other nuanced behavior associated with attention in multimodal learning environments, which may be needed to fully measure the use of metatextual knowledge. Eye tracking in conjunction with TAP data verbalizations would offer more data to trace where and for how long learners focus their attention and their gaze during the learning task, such as if learners preview material by reading only bold section headings or skim through entire passages of texts. Data captured through gaze-behavior could include: how long a learner took to preview material through skimming prior to further engagement, what words embedded in the text caught the learner's attention, how many times during the learning task the individual's attention drifted to other components of a website, such as a video, related article, or a pop-up ad or even where a reader slowed down or changed the their reading pace. Use of eye tracking in conjunction with TAP data would have enhanced the methodological approach by providing further insight into behavior that learners may have failed to verbalize because they were unaware of where they were looking.

Statistical limitations also existed in this study. When working within cases in the data set, I inputted zeroes for participants who did not access particular websites to have a large enough sample size and appropriate variance. Participants who did not access the websites at all received zeroes and participants who accessed the websites but did not engage in SRL processing also received zeroes. For the purpose of the exploratory study, this was a limitation but one that still provided initial information as to the behaviors associated with SRL processing. To avoid this limitation, I would design a study where participants are assigned the same documents or are directed to visit each of the texts in the online environment. They would not have the freedom to search for information online and nor have the freedom to navigate any and all available research on vitamins. It would also be useful to provide time constraints per visit to the required websites or limit engagement with hyperlinks within documents that take learners into individualized pathways. Or, the directions for the learning task could include a statement that participants are required to engage in each website.

Implications of the Study

One purpose of this study was to investigate ways in which learners displayed metatextual knowledge during an online reading task of a complex science topic. This study illustrated the frequency with which learners engaged in behaviors related to metatextual knowledge, such as noticing hyperlinks, lists, or videos on the website as they navigated varied and multiple documents. Reader pathways in online reading are self-generated pathways that tend to move from hyperlink to hyperlink (Castek & Coiro, 2015; Coiro & Dobler, 2007). As such, readers engaging in an online task may generate a reader pathway consisting of multiple media sources, including magazine articles, journal articles, medical websites, and video and graphic representation of information with varied levels of multimodal information. Although findings indicated learners engaged in more surface-level than deeper use of metatextual knowledge, the noticing of bold headings was a statistically significant predictor of learning. This adds to the literature on specific microlevel metatextual processes that relate to learning gains that can inform future instruction in science literacy, as well as future directions in exploring differences in metatextual knowledge use across multiple documents and through reader pathways. The M15+ variables, which include noticing hyperlinks, using headings to infer the expectation of adequacy of content, and noticing bold headings, lists, and bullets indicated that a combination of organization, labeling, and topic and functional identifiers statistically significantly related to learning. This combination of intertextual strategies can also inform instruction as to the variety of metatextual knowledge within successful online learning and the cognitive processes related to both structure and function of texts in online environments. The multitiered approach to data analysis, using both microlevel and macrolevel variables has been utilized in past SRL research (e.g., Greene et al., 2014, 2018). Findings from this study further support continued use of a multitiered approach when engaging in complex learning environments online and further enhance the significance of the learning context and its role in learning.

Findings from this study may also enhance the literature on SRL processes during online learning with multiple documents. As online learners engage with multiple documents across varied genres when learning, they are likely to encounter various text types, inclusive of description, problem/solution, and argumentation texts presenting a claim, evidence, and reasoning for a scientific argument. These findings have indicated that learners more frequently engage in different planning, monitoring, and strategy use when they encounter different text types with different structural components. The awareness of the structural components of different text types has been shown to increase learners' ability to organize what they have learned into main ideas and summaries and increase levels of comprehension (Dymock, 2005; Meyer et al., 2011; Roehling et al., 2017; Wijekumar et al., 2012). When learners have prior knowledge about particular text types, such as the structure of argumentation texts, they are more likely to engage in strategy use that will aid recall and retention of information (Richgels et al., 1987). In online environments, the use of metatextual knowledge has been shown to increase a learner's efficiency in locating information (Rouet & Coutelot, 2008). The findings from this study then expand possible directions for SRL researchers to explore regarding the important processes, skills, and behaviors related to learning from online texts with identified textual and structural elements.

In addition, findings from this study provide potential implications for additional scholarship using artificial intelligence to scaffold online learners. I envision computer algorithms designed from in-the-moment learner behavior, captured through in-the-moment gaze behavior and think alouds during the process of a learning task. For example, eye-tracking software captures gaze behavior. Speech streaming software captures specific language associated with successful learning for the particular task. An algorithm then determines when a learner fails to spend a significant amount of time within a particular section of a website or fails to consider specific key points within a learning environment. A speaking avatar can utilize this data to scaffold learners through their learning task by providing hints. This avatar could intervene within the learning environment and provide prompts or ask reflective questions for learners to engage in metacognitive reflection on strategy use or could direct learner behavior towards particular sections of text, to use particular metatextual knowledge embedded in the text, or to adapt their strategy use, and therefore to influence their leaning. This avatar could also, in effect, provide direct instruction for imminent behavior change that impacts learning. Learners could receive extrinsic rewards that include personalizing their avatar with specific clothing, headwear or accessories to contribute to creating an interactive environment, engaging in the task, or even personalizing their learning. Data could be collected on the frequencies related to the types of hints online learners need and the particular ways in which metatextual strategies can be enhanced through drawing readers' attention to relationships amongst topics.

Current online tools, such as CAST Science Writer for example, could benefit from research tied to the use of scaffolding metatextual knowledge and skills in online environments. Designers of this tool used an underlying framework that captures structural components of texts, highlights them for learners, and creates specific connections between structural components of texts to improve reading, writing and comprehending science. From a more traditional standpoint, this study has instructional implications that address ways educators can enhance their curriculum or pedagogical practice in both upper-level courses and within online learning through inclusion of metatextual knowledge of the structural and functional components of a variety of texts and aspects of multi-modal information. Henderson and colleagues (2018) highlighted the need for different instructional emphasis on strategies and approaches to science practices, for example and the differences in assessing argumentation that many science educators face in 21st century teaching and science learning (Henderson et al., 2018).

Future Directions

In order to gain further access to the ways in which learners use metatextual knowledge on a deeper level and to assess the role that text types have in SRL processing, it would be useful to conduct an intervention study. One group would receive explicit instruction on how to use structural, functional, and organizational features. Instruction could include how to use bold headings to infer content in a section and how to use that information to locate information when needed. This group could receive instruction on how to use signal words to infer meaning of a passage. Group members could receive instruction on how to use structural components of text to preview material prior to engaging in the text as a way determine adequacy of content towards the task. The control group would not receive explicit instruction. I anticipate that those participants who received explicit instruction would have higher levels of recall on declarative knowledge questions, would be able to locate information more quickly, would display more metatextual knowledge in the TAP data, and would have higher learning gains than the control group.

On a more nuanced level, the interaction between text types and the effects the interaction has on learning in science domains is another opportunity to explore. There are a variety of approaches to take on this level. I would provide each group with four different text types. One group would read the refutation text last. One group would read the refutation text first. One group would read the refutation text in the middle of the text order. I would trace the SRL processing within each text and compare the different reader paths to see if reading a refutation text in a specific place in the path affects SRL processing behavior in the texts that come after. I would be interested in seeing if order of text types relates to learning gain.

Currently, I am unaware of any researchers in metatextual studies who have explored the order of text types. Learning more in this area would be useful because refutation texts are structured specifically to change perceptions (Alvermann & Hague, 1989; Chambliss, 2002). It would be interesting to explore if and when different SRL processes occur based on the order of text types. I would assess learning for each group. Future research could include differentiating text types across domains. One group could receive all science texts and one group could receive all history texts. Each group would receive the same text types within their domain. Text complexity would be similar across both domains. Text types within domains would also be consistent. It would be interesting to see if metatextual knowledge differed by domain. I would also do a case study analysis to compare metatextual knowledge in argumentative texts in both science and history by comparing metatextual knowledge in refutation texts in each domain. Lastly, I would be interested in exploring the sequencing patterns of metatextual knowledge and SRL processes. For example, I would be interested to learn if there are different text types that, because of structural and functional elements, create conditions where learners engage in inferencing or summarizing strategies. I would look particularly at the use of bold headings used as topic identifiers to explore when learners notice them, what process they engage in prior to noticing, and what processes they engage in after noticing them. One problem with these future studies is they are path directed and therefore do not mimic the varied and unique path that learners engage in when learning online. More research is needed to investigate how learners employ different higher level strategies tied to metatextual knowledge, how explicit instruction in metatextual knowledge influences learning, and how learners engage with metatextual knowledge across domains. It is exciting to consider the potential research opportunities based on the findings from this study.

Conclusion

In this study, the use of metatextual knowledge in undergraduate and graduate students was explored to identify ways in which learners utilize metatextual knowledge within a complex science task, to determine if use of metatextual knowledge related to learning gains, and to examine the effects of text type on macrolevel SRL processes. Study findings revealed that users integrated noticing behaviors related to metatextual knowledge to show awareness of structural and organizational metatextual features such as bullets, lists, or graphics. Few of these instances of metatextual knowledge were statistically significantly related to learning gains. From a microlevel, only learners who used bold headings as topic identifiers showed significant learning gains. However, when using a multitiered approach, data-driven results of the processes positively correlated at the .15 cutpoint significantly related to learning gains. Findings regarding the benefits of noticing hyperlinks, using headings to infer the expectation of the adequacy of content, and noticing bold, lists, and bullets indicated that a combination of both structural and functional components of texts related to learning. This aligns with past research from traditional literacy (Lemarié et al., 2008) substantiating the incorporation of metatextual knowledge into online learning. Research findings indicated that when participants engaged with various text types, a significant relationship existed between text type and planning, strategy use, and monitoring, which are the macrolevel processes associated with learning. More nuanced was the relationship between text types and macrolevel SRL processes. These findings suggest a need for further study on the individual characteristics of texts from a metatextual standpoint as contextual elements relate to learning in science domains.

Findings in this study indicated that the knowledge, skills, and processes learners engage in during a complex science task in an online environment continue to relate to learning in online environments. Previous research has established the importance of the variety of skills, strategies, and processes required for successful learning in online environments particularly related to comprehension (Afflerbach & Cho, 2008; Cho, 2013; 2014; Cho & Afflerbach, 2015) and within SRL literatures (Greene & Azevedo, 2007; Greene et al., 2014; Greene et al., 2018), the importance of individual characteristics (Fox, 2009), and the ways in which context matters in learning environments (Greene et al., 2014, 2018).

Metatextual knowledge context is important, but the variety of text types within domains—particularly science domains—relates to the frequency of learners' SRL processing. Therefore, there exists a need to further examine the structural and organizational features within websites and texts to better understand the complexity of processes learners engage in and the knowledge, skills, and dispositions required for online learning. Research has indicated gaining deeper conceptual knowledge within online learning environments requires complex SRL processes (Winne & Hadwin, 1998; Zimmerman, 2000). There is room in SRL research related to metatextual knowledge for methodological improvements based on combined technologies of eye tracking software and TAP data. More so, there is room to explore both the ways in which metatextual knowledge can enhance learning and the ways in which text features can enhance SRL processes.

APPENDIX A: SELF-REGULATED LEARNING CODING SCHEME

SRL Macrolevel Category: Planning

Microlevel category	Code	Description
Planning	PLAN	Learner stated two or more learning or time goals
Recycle Goal in Working Memory	RGWM	Restating the goal (e.g., question or parts of a question) in working memory
Sub-goal	SG	Learner articulates a specific sub-goal that is relevant to the experiment-provided overall goal. Must verbalize the goal immediately before clicking on the relevant subsection AND must immediately carry out some action relevant to the goal [i.e., can't drop the goal immediately]
Time Planning	TP	Participant refers to the number of minutes remaining AND indicates whether a goal can be met during that time

SRL Macrolevel Category: Monitoring

Microlevel category	Code	Description
Content Evaluation (Plus)	CE+	Stating that any just-seen text, diagram, or video is relevant to learning or is good
Content Evaluation (Minus)	CE-	Stating that any just-seen text, diagram, video is irrelevant or not helpful to learning
Content Evaluation (Neutral)	CE	Evaluating any just-seen text, diagram, or video without definitive conclusion regarding relevance to learning.
Expectation of Adequacy of Content (Plus)	EAC+	Expecting that a certain content (e.g., section of text, diagram, video) will be adequate given the current goal
Expectation of Adequacy of Content (Minus)	EAC-	Expecting that a certain content (e.g., section of text, diagram, video) will not be adequate given the current goal
Expectation of Adequacy of Content (Neutral)	EAC	Evaluating adequacy of presented content given the current goal without definitive conclusion
Emotion Monitoring	EM	Participant realizes that he/she is having an emotional response due to some aspect of the learning task.
Feeling of Knowing (Plus)	FOK+	Learner is aware of having read or learned something in the past and having some understanding of it
Feeling of Knowing (Minus)	FOK-	Learner is aware of not having read or learned something in the past
Feeling of Knowing (Neutral)	FOK	Learner is aware of having read or learned something in the past but does not feel certain of the content or understanding it.
Judgment of Learning (Plus)	JOL+	I get it! OR This makes sense
Judgment of Learning (Minus)	JOL-	I don't get it! OR This doesn't make sense
Judgment of Learning (Neutral)	JOL	I kind of get it, but I kind of don't. OR This does and doesn't makes sense to me.

Microlevel category	Code	Description
Monitor Progress Toward Goals	MPG	Assessing whether previously set goal has been met
Monitor Use of Strategies	MUS	Participant comments on how useful a strategy is/was
Self-Questioning	SQ	The participant asks a question relevant to the task, but does not articulate a specific plan to investigate the answer. Indicates that the participant has recognized a gap in understanding.
Time Monitoring	TM	Participant refers to the number of minutes remaining

SRL Macrolevel Category: Strategy Use

Microlevel category	Code	Description
Coordinating Informational Sources	COIS	Using pointing or verbalizing the matching of elements of two different representations, e.g., drawing and notes. Either representation can be in the environment or in participant's notes.
Control Video	CV	Using pause, start, rewind, or other controls in the digital animation.
Draw	DRAW	Making a drawing or diagram to assist in learning
Evaluate Content as Answer to Question	ECAQ	Statement that what was just read and/or seen meets an experimenter posed question
Emotion Regulation	EM	Participant actively attempts to control emotional response to some aspect of the learning task.
Inferences	INF	Drawing a conclusion based on two or more pieces of information that were read, seen, or heard in the hypermedia environment in same time period, roughly
Knowledge Elaboration	KE	Elaborating on what was just read, seen, or heard with prior knowledge
Memorization	MEM	Learner tries to memorize text, diagram.
Prior Knowledge Activation	PKA	Searching memory for relevant prior knowledge either before beginning performance of a task or during task performance
Read Notes	RN	Learner reads over his or her own notes, drawings.
Rereading	RR	Rereading or revisiting a section of the hypermedia environment
Search	SEARCH	Searching the hypermedia environment
Select New Informational Source	SNIS	Using features of the hypermedia environment to access a new representation and/or a new section of the environment (clicking on hyperlinks, items in Table of Contents, back arrow)
Self-Knowledge Activation	SKA	The participant verbalizes that he or she is going to invoke a strategy because it is helpful to him/her personally. Or participant verbalizes that he/she is NOT going to invoke a strategy because it is NOT helpful to him/her.
Summarization	SUM	Verbally restating what was just read, inspected, or heard in the hypermedia environment
Taking Notes	TN	Learner writes down information

SRL Macrolevel Category: Interest

Microlevel category	Code	Description
Interest (Plus)	INT+	Learner has a certain high level of interest in the task or in the content domain of the task.
Interest (Minus)	INT-	Learner has a low level of interest in the task or in the content domain of the task, used for any representation.
Interest (Neutral)	INT	Learner makes some interest-related expression regarding the task or in the content domain of the task indicating neither high nor low interest.

APPENDIX B: RESEARCHER-DESIGNED SEARCH RESULTS PAGE

Search results for **"effectiveness of vitamins"**

Do Vitamins Really Work?
Watch CBS television online. Find CBS primetime, daytime, late night, and classic tv episodes, videos, and information.
http://www.youtube.com/watch?v=9YEunhOwu5I

Dr. Oz answers: 'What supplements do you take?'
Get answers to your health questions from DR. OZ and other leading doctors, hospitals, associations, authors, and people just like you.
http://www.youtube.com/watch?v=JKU0MkqNAN0&feature=related

Fortify Your Knowledge About Vitamins
The Food and Drug Administration (FDA or USFDA) is an agency of the United States Department of Health and Human Services, one of the United States ...
http://www.fda.gov/forconsumers/consumerupdates/ucm118079.htm

Vitamins: What to Take, What to Skip
Health.com and Health Magazine provide up-to-date news and information ... Health.com combines expert medical information with the insights of real patients.
http://www.health.com/health/gallery/0,,20506267,00.html

More bad supplement news: Vitamin E may be risky for prostate
Msnbc.com is a leader in breaking news, video and original journalism. Stay current with daily news updates in health, entertainment, business, science, ...
http://vitals.msnbc.msn.com/_news/2011/10/11/8273189-more-bad-supplement-news-vitamin-e-may-be-risky-for-prostate

Multivitamins Don't Work!
60+ bloggers selected on the basis of their originality, insight, talent, and dedication provide up-to-date coverage of their different scientific fields.
http://scienceblogs.com/scientificactivist/2010/01/multivitamins_dont_work.php

Vitamins and Supplements: Do They Work?
Health articles on men's, women's health, and children's health issues. Get health information about the Best Hospitals, Best Health Plans, and diseases and ...
http://health.usnews.com/health-news/diet-fitness/diet/articles/2008/12/09/vitamins-and-supplements-do-they-work

Fortify Your Knowledge About Vitamins
The leading source for trustworthy and timely health and medical news and information. Providing credible health information, supportive community, and ...
http://www.webmd.com/fda/fortify-your-knowledge-about-vitamins

Google.com
The leading source for trustworthy and timely health and medical news and information. Providing credible health information, supportive community, and ...
http://www.google.com

APPENDIX C: DEMOGRAPHIC QUESTIONNAIRE

Please enter your participation id.

1. Gender
   - Male
   - Female
2. Age
3. Year in school
   - Freshman
   - Sophomore
   - Junior
   - Senior
   - Other

4. If not a freshman, sophomore, junior or senior, please fill in:

5. Major

6. Current overall GPA (across all classes)

APPENDIX D: INTERNET SELF-EFFICACY MEASURE

Please enter your participation id number.

1. When researching on the Internet, I feel confident that I can find useful information on my research topic
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

2. I can find useful information related to my topic of research in a reasonable amount of time.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

3. I feel confident using search engines to find information related to my topic of research.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

4. I feel very overwhelmed when a long list of links appears when I use search engines for my research topic.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

5. I feel confident that I can determine whether a website is useful or not.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

6. I feel confident using more than one source on the Internet to gain useful information on my research topic.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

7. I feel confident that I know which websites are considered legitimate and which are not when researching a topic online.

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

8. When researching with the Internet, I feel confident that I can select appropriate links in a text to gain further understanding of my topic of interest.

   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

9. I feel confident integrating text, images and videos from multiple sources to gain an understanding of the material on my research topic.
   - Strongly Disagree
   - Disagree
   - Agree
   - Strongly Agree

APPENDIX E: VITAMIN KNOWLEDGE PRETEST

Pretest of Vitamin Knowledge

1 Which of the following statements is true about vitamins and/or minerals?

a) The 12 essential vitamins are known by letters including: A, B, C, D, E, F, and K.
b) Calcium, iron, iodine, and silicate are all examples of minerals that the body needs for proper functioning.
c) Extra boosts of vitamins and minerals have a strong track record for curing diseases.
d) Vitamin and mineral requirements are different for every person and are affected by all of these factors: age, sex, and physical activity.
e) All vitamins and minerals are very sensitive to cooking processes, like heating.

2 Which statement is true regarding manufactured dietary supplements?

a) Most experts believe that food and dietary supplements are equally effective ways for the body to acquire needed vitamins and minerals.
b) Manufactured dietary supplements maintain their potency well beyond their expiration dates.
c) Dietary supplement companies are required to meet with approval from the U.S. Food and Drug Administration before their products are sold on the market.
d) The most commonly "overdosed" vitamin and mineral supplements are Vitamin C and zinc.
e) Manufactured dietary supplements can come in all of the following forms: pill, capsule, lozenge, and gummy bear.

3 Which of the following general statements is most likely to be / given by a medical professional, such as a doctor or pharmacist?

a) Since vitamins and minerals exist in the body in very small amounts, it is usually not necessary to modify the intake of dietary supplements when you have a medical condition.
b) Strict vegetarians and vegans are limited in their food sources for calcium, iron, and B12, so they are in danger of deficiencies in these nutrients.
c) People over 50 years old have difficulty breaking down Vitamin B12 in its artificially produced form, so they should not take a supplement for that vitamin.
d) After menopause, folic acid supplements are not considered important for women because the main benefits have to do with pregnancy and the body requires much less folic acid later in life.
e) As an alternative to Viagra, taking large amounts of zinc through supplements should improve sexual activity without negative side effects to your health.

4 Which statement is true regarding Vitamin D?

a) The more Vitamin D a body gets, the healthier it will be.
b) The body is capable of making Vitamin D when exposed to sunlight.
c) Vitamin D helps metabolize the zinc in your body.
d) Large amounts of Vitamin D have been proven to prevent cancer.
e) Salmon, peanuts, and beef liver are all-natural foods that contain large amounts of Vitamin D.

5 Which of these food sources provides the least amount of calcium?

a) Almonds
b) Cow milk
c) Brown rice
d) Tofu
e) Goat cheese

6 Which statement is true regarding the interaction of nutrients and / the body?

a) Vitamin E improves liver functioning by promoting free radicals in the body.
b) Vitamin D facilitates the body's absorption of calcium.
c) High levels of folic acid reduce the body's need for other B vitamins.
d) Vitamin K increases the body's response to Vitamin C.
e) Iron is important for supporting nerve functioning.

7 Which statement is true about water-soluble vitamins?

a) They are easily absorbed by the body.
b) Vitamins A and C are water-soluble vitamins.
c) The body stores these vitamins for later use as needed.
d) "Antioxidants" is another name for them.
e) There is no risk of overdose and therefore not risk of bodily harm from mega-dosing.

8 Which statement agrees with current medical research on vitamins / and minerals?

a) There is strong evidence that antioxidants have the ability to prevent diseases like cancer.
b) Vitamin C in doses over 2000mg prevents a person from catching a cold.
c) Large amounts of B12 contribute to athletic performance by giving you energy.
d) Fat-soluble supplements need to be taken with fatty foods to maximize their benefits.
e) Older, postmenopausal women require more iron than younger women of childbearing age.

APPENDIX F: VITAMIN KNOWLEDGE POSTTEST

Posttest

Imagine that you are taking a final exam in a public health elective course. Please respond to this question in the space below: "If your friend, who is a normal healthy adult, asked you whether he or she should start taking a daily vitamin pill, what would tell this person to do and why? Be sure to include any relevant evidence that supports your advice."

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