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# The Effect of Elaborative Interrogation on the Synthesis of Ideas from Multiple Sources of Information

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The Effect of Elaborative Interrogation on the Synthesis of Ideas from

Multiple Sources of Information

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by

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**Chapter I**

**Introduction**

As the information landscape has expanded in the last few decades, students face the ever challenging tasks of navigating a complex, disorderly landscape as well as synthesizing ideas from multiple sources of information. Academic libraries support the institutional goals by providing information literacy instruction to students on how to find and use information to fulfill their academic goals. The current predominant model of information literacy instruction in academic libraries, however, mainly focuses on how to find relevant information sources for their academic information needs but overlooks how students use gathered information sources to synthesize ideas. The Association of College and Research Libraries' (ACRL) Framework for Information Literacy for Higher Education (ACRL, 2016) highlights the ability to synthesize ideas from multiple sources of information as one of the key knowledge practices through which students show their development. The purpose of this experimental study is to examine the effectiveness of elaborative interrogation instructional strategy on students' ability to integrate and transform ideas gathered from multiple sources of information.

**Background of the Problem**

Academic libraries have a long, rich history in supporting the educational goals of the university. Terms such as library orientation, library instruction, bibliographic instruction, and user education have all been part of professional vocabulary (Grassian & Kaplowitz, 2009). The term "information literacy" was first used in 1974 in a report written on behalf of the National Commission on Libraries and Information Science by Paul Zurkowski (ALA, 1989). According to Zurkowski, an information literate individual is someone who has learned to use a wide range of information sources in order to solve problems at work and in his or her daily life (ALA,

1989). The modern information literacy movement of the 1980's and 1990's acknowledged and built upon the rich history of bibliographic instruction.

The American Library Association (ALA) presidential committee described the information literate individual as someone who has the ability to recognize the information need and the ability to locate, evaluate, and use information effectively (ALA, 1989). An information literate individual is one who has learned how to learn. Reviewing the numerous definitions throughout the last few decades, Grassian and Kaplowitz (2009) argue that information literacy has been described in a variety of ways—as a process, a skill set, a competence, an attitudinal or personality trait, a set of abilities, a way to help people contribute positively to the learning community and to society, and a construct that is created by the ways in which a person interacts with information. Critical thinking and evaluation as well as the ethical use of information have all been cited as integral to conceptualizing information literacy. Later, scholars such as Swanson (2004) and Elmborg (2006) stressed that to be information literate in the 21$^{st}$ century, one must understand how information works as social, political, and cultural force and that our interactions with information contribute to these forces—giving the concept a critical outlook (Grassian & Kaplowitz, 2009).

Emphasizing the significance of instruction in academic libraries, Wang (2013) argues that the digital revolution had a strong impact on the evolution of library instruction. Instruction became an integral part of academic libraries with the focus on competencies in information and communication technologies, user-centered approaches to teaching and learning, outreach, and learning outcomes assessment (Wang, 2013). With the information age, academic libraries saw tremendous growth in reliance on electronic information sources for teaching, learning, and

research (Wang, 2013). This reliance prompted formalized instruction and assessment of students' ability to locate and use information effectively.

**Instruction in Academic Libraries**

The Association of Colleges and Research Libraries (ACRL) Information Literacy Competency Standards for Higher Education was the first document that guided information literacy instruction and assessment in higher education. Since its implementation, the ACRL standards were widely adopted by academic librarians to guide information literacy instruction and assessment (Grassian & Kaplowitz, 2009). Information literacy in the ACRL standards is defined as a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use the needed information effectively (ACRL, 2000). Additionally, the standards codify performance indicators for outcomes for information literacy as 1) determining the nature and extent of the information needed; 2) accessing needed information effectively; 3) evaluating information critically; 4) using information to accomplish a specific purpose; and 5) understanding the economic, legal, and social issues surrounding the use of information and using information ethically and legally (ACRL, 2000).

Even though the standards explicitly stated performance indicators and indicative outcomes that could be used to design information literacy instruction, they were critiqued by many practitioners and scholars as having a narrow, skill-based, and mechanistic view of information literacy. Foasberg (2015) argues that the standards, which define information literacy as a set of abilities and enumerate in some detail what the information literate student should be able to accomplish, advance a positivistic understanding of the nature of information—imagining it as a commodity external to the student. The standards portray students as individuals who acquire these skills through practice. In the language of the standards,

information usually refers to artifacts rather than their contents. Thus, the standards present information sources as goods that can be acquired and that the student acquires a commodity, rather than participating in a conversation or integrating information sources with her existing knowledge base (Foasberg, 2015).

Another critique of this decontextualized, skill-based information literacy instruction (Elmborg, 2006; Foasberg, 2015; Swanson, 2004; 2005) originate from the standpoint of rhetoric and composition, both of which consider context, conversation, and active participation in literacy of all kinds. When a student engages in research, she does not simply extract and record information, as the second standard suggests, but rather wrestles with the content, draws connection with what she already knows, and generates more questions (Foasberg, 2015).

In response to these critiques of the standards, the latest conceptualization of information literacy came in the form of ACRL Framework for Information Literacy for Higher Education (ACRL, 2016). The framework includes interconnected information literacy threshold concepts (Meyer & Land, 2005) as well as the notion of metaliteracy proposed by Mackey and Jacobson (2011) and offers a renewed vision of information literacy as an overarching set of abilities that unifies such concepts as media literacy, visual literacy, digital literacy, and information literacy in which students are both consumers and creators of information and are active participants in collaborative spaces (ACRL, 2016). The notion of metaliteracy demands behavioral, affective, cognitive, and metacognitive engagement with the constantly evolving information ecosystem. The framework also includes knowledge practices which are demonstrations of ways in which learners can increase their understanding of these information literacy concepts and dispositions which describe ways in which to address the affective, attitudinal, or valuing dimensions of learning (ACRL, 2016).

This new and expanded conceptualization of information literacy in the framework emphasizes dynamism, flexibility, individual growth, and metacognitive engagement with information (Foasberg, 2015). The student in the framework is replaced by the learner who is on a continuum—growing from a novice into an expert. The framework, thus, not only acknowledges but underscores that even novice learners are capable of evaluating information sources and integrating ideas derived from a variety of sources.

The new framework of information literacy for higher education (ACRL, 2016) depends on these core ideas of metaliteracy, with special focus on metacognition, or critical self-reflection, as crucial to becoming more self-directed in a rapidly changing information ecosystem. Information literacy, in the new framework, is defined as a "set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning" (ACRL, 2016, p. 3).

In addition, six frames guide the understanding of information literacy threshold concepts. Table 1 on the following page describes the individual frames.

Table 1

*Information Literacy Frames*

| Frame | Description |
| --- | --- |
| **Authority is constructed and contextual** | Information resources reflect their creators' expertise and credibility, and are evaluated based on the information need and the context in which the information will be used. Authority is constructed in that various communities may recognize different types of authority. It is contextual in that the information need may help to determine the level of authority required. |
| **Information creation as a process** | Information in any format is produced to convey a message and is shared via a selected delivery method. The iterative processes of researching, creating, revising, and disseminating information vary, and the resulting product reflects these differences. |
| **Information has value** | Information possesses several dimensions of value, including as a commodity, as a means of education, as a means to influence, and as a means of negotiating and understanding the world. Legal and socio-economic interests influence information production and dissemination. |
| **Research as inquiry** | Research is iterative and depends upon asking increasingly complex and new questions whose answers in turn develop additional questions or lines of inquiry in any field. |
| **Scholarship as conversation** | Communities of scholars, researchers, and professionals engage in sustained discourse with new insights and discoveries occurring over time as a result of varied perspectives and interpretations. |
| **Searching as strategic exploration** | Searching for information is often nonlinear and iterative, requiring the evaluation of a range of information sources and the mental flexibility to pursue alternate avenues as new understanding develops. |

*Note*: Adapted from ACRL (2016).

The key characteristic of the new framework, as evident in the descriptions above, is how students move along the continuum and experience these information literacy threshold concepts or frames. Each frame has its associated knowledge practices through which students demonstrate their growth continuum from novice to expert as well as dispositions that point to the cognitive and behavioral dimensions of their learning. Detailed descriptions of each individual frame along with their associated knowledge practices and dispositions are included in Appendix A. Despite the accompanying knowledge practices, the nebulous nature of the framework presents a challenge and a departure from the prescriptive, universal set of outcomes that practitioners used as a guiding document in the previous ACRL Information Literacy Competency Standards for Higher Education (ACRL, 2000).

**Statement of the Problem**

Academic librarians identify instructional work as integral to their professional identity, but few feel confident in their pedagogical expertise (Julien & Genuis, 2011). Academic librarians have master's level education but few have significant formal instructional training. Others have called for a closer examination of the connection between information literacy instruction and theoretical assumptions about learning (Diekema, Holliday, & Leary, 2011; Grassian & Kaplowitz, 2009). Furthermore, research in domain knowledge use suggests that instructional training can aid professionals make use of their extensive domain knowledge and studies show a significant effect of explicit training for teachers in their underlying theory on student performance (Alexander, White, Haensly, & Crimmins-Jeanes, 1987; Alexander, 1992). Therefore, detailed articulation of how students acquire these skills based on cognitive and learning science and how these instructional strategies can be employed in the context of

information literacy instruction to promote successful instructional outcomes is strongly needed in the profession.

For both practitioner and researcher, the new framework of information literacy for higher education presents itself as a progressive document, one that invites and encourages careful thinking of information literacy pedagogy and critical assumptions about the theories underlying the information literacy instruction practice (Foasberg, 2015). As the official document notes:

> The Framework opens the way for librarians, faculty, and other institutional partners to redesign instruction sessions, assignments, courses, and even curricula; to connect information literacy with student success initiatives; to collaborate on pedagogical research and involve students themselves in that research; and to create wider conversations about student learning, the scholarship of teaching and learning, and the assessment of learning on local campuses and beyond. (ACRL, 2016, p. 3)

Since its formal introduction to the practitioner librarians, the new framework has presented unique challenges not only in terms of creating local learning outcomes based on the individual knowledge practices within the frames, but also in creating, delivering, and assessing instruction. As evident in many scholarly communication venues, this is a turning point filled with both excitement and anxiety in the profession. Academic librarians are a willing audience who desperately desire the help to deliver information literacy instruction based on this new progressive yet abstract framework.

The body of literature on information literacy instruction is vast. However, generalizable empirical research on information literacy instruction built on the theoretical foundations of cognitive science is very limited. As the review of the literature in Chapter II points out, an integral missing segment in this body of literature is the connection between what cognitive and learning science research tells us about how students acquire these skills and in turn, how instructional librarians can best adopt findings from cognitive science regarding learning to create effective instructional techniques (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013), which improve comprehension, and synthesis of ideas from multiple documents into their practice (Perfetti, Rouet, & Britt, 1999; Wiley & Voss, 1999).

Educational psychologists have developed and evaluated several effective instructional strategies that help students achieve their learning goals in a variety of different educational contexts (Dunlosky et al., 2013; Ormrod, 2013). Some of these strategies include elaborative interrogation, self-explanation, summarization, practice testing, distributed practice, and interleaved practice (Dunlosky et al., 2013). There are many benefits to approaching instruction based on cognitive principles that facilitate learning. For example, prompting students to activate their prior knowledge and make connections with the to-be-learned material can facilitate comprehension as well as organize and structure newly acquired knowledge. Similarly, providing targeted feedback along with distributed practice can strengthen the performance on the application of procedural skills (Hattie & Yates, 2013; Ormrod, 2013). The extent to which these individual strategies are effective depends on factors such as learning tasks (memorization, problem-solving, comprehension), learning conditions (whether students work alone or in groups, online, blended, or face-to-face), materials (mathematical problems, text

comprehension), and student characteristics (age, ability, and level of prior knowledge) (Dunlosky et al., 2013).

Elaborative interrogation strategy involves prompting learners to generate an explanation for an explicitly stated fact. The primary cognitive mechanism that accounts for the effect of elaborative questioning is that it enhances learning by facilitating the integration of new information with learners' existing prior knowledge (Dunlosky et al., 2013). The cognitive benefits of explanations extend beyond integration of new material and help learners with organization and retrieval—making this instructional strategy particularly beneficial for the higher order cognitive learning tasks such as integration and transformation of ideas gathered from multiple information sources. A review of relevant literature highlights how elaborative interrogation strategy has been employed and deemed effective in a variety of different contexts. For example, generating explanations, analogies, or examples embedded in a text with cognitive prompts such as "Which examples can you think of that illustrate, confirm your interpretations?" have significantly improved learning outcomes. Elaborations as personal examples or restatements of important features of concepts have similarly been effective (Hannon, 2012). Prior research strongly suggests that cognitive benefits of explanatory questioning can facilitate learning and is effective across different contexts (Dunlosky et al., 2013).

**Research Questions**

The purpose of this study is to test the effectiveness of the elaborative interrogation instructional strategy on the synthesis of ideas from multiple sources of information. The primary research questions guiding this study are:

**RQ1:** Do elaborative interrogation prompts improve transformation of ideas gathered from multiple sources of information?

**H1:** Participants who receive elaborative prompts would perform better on transformation measure.

**RQ2:** Do elaborative interrogation prompts improve integration of ideas gathered from multiple sources of information?

**H2:** Participants who receive elaborative prompts would perform better on integration measure.

**Significance of the Study**

This study is important for multiple reasons. First, the study will contribute to the new ACRL Framework for Information Literacy for Higher Education (ACRL, 2016) by linking much needed evidence-based guidance for instruction of the nebulous frames. As noted previously, there is little generalizable empirical research based on cognitive science to guide information literacy instruction practice. This study addresses this gap. Even though the focus of this study is on the "Research as Inquiry" frame which includes "the ability to synthesize ideas gathered from multiple sources" as one of its associated knowledge practices, it provides a promising long-term, cross-disciplinary research partnership in terms of linking evidence-based guidance for instruction based on cognitive science principles to other frames and their associated knowledge practices (ACRL, 2016). Second, it contributes to the existing body of

literature on elaborative interrogation—expanding the scope of utility and effectiveness of this particular instructional strategy. One of the significant aspects of the study is testing elaborative interrogation on more abstract knowledge as well as higher cognitive tasks such as integration and transformation of ideas. And finally, it contributes to the existing body of literature on multiple documents comprehension (Perfetti et al., 1999; Wiley & Voss, 1999).

**Summary**

The new Framework for Information Literacy for Higher Education (ACRL, 2016) with its nebulous frames and knowledge practices calls for evidence-based guidance for information literacy instruction. Examining one of the frames entitled "Research as Inquiry," which includes the "ability to synthesize ideas gathered from multiple sources" as one of its associated knowledge practices, this study tests the effectiveness of elaborative interrogation instructional strategy on the measures of integration and transformation of ideas from multiple sources of information.

**Chapter II**

**Review of Related Literature**

This study examined the effectiveness of elaborative interrogation instructional strategy on integration and transformation of ideas from multiple sources of information. The review of related literature covers three main areas. First, studies highlighting the use of elaborative interrogation instructional strategy are discussed in the context of present study. Second, active-constructive-interactive framework (Chi, 2009) provides a theoretical foundation for identifying a hierarchy of different learning activities, their associated cognitive processes, and how these mechanisms relate to elaborative interrogation prompts being investigated in the present study. Third, research in multiple document comprehension is discussed in light of active-constructive-interactive framework and elaborative interrogation literature to scaffold the hypotheses that multiple source presentation along with elaborative interrogation prompts will significantly improve the integration and transformation of ideas.

**Elaborative Interrogation**

Research in cognitive science has identified different learning techniques that help students achieve learning outcomes (Dunlosky et al., 2013). Techniques such as elaborative interrogation, self-explanation, summarization, highlighting, underlining, keyword mnemonic, imagery use of text, rereading, practice testing, distributed practice, and interleaved practice have been found useful in different learning contexts (Dunlosky et al., 2013).

Elaborative interrogation is a learning strategy that highlights the cognitive benefits of explanation and involves prompting learners to generate an explanation for an explicitly stated fact. The explanatory prompts differ in terms of specificity across studies—for example, the prompts include questions such as "Why is this true?" "Why does it make sense," to simply

"Why?" (Dunlosky et al., 2013). Hannon (2012) defines elaborations as "any type of enhancements that clarify the original to-be-remembered information with respect to other information" (p. 299). Elaborations can be instructor-generated explanations, analogies, or examples embedded in a text with cognitive prompts such as "Which examples can you think of that illustrate, confirm your interpretations?" Elaborations are also learner-generated personal examples or restatements of important features of concepts (Hannon, 2012). An instructional strategy similar to elaborative interrogation is self-explanation. The prompts used in self-explanation studies, however, differ in specificity and are typically more specific. Self-explanation prompts can easily be confused with elaborative interrogations, but both strategies essentially involve having students explain some aspect of their processing during learning. Dunlosky et al. (2013) argue that the literature on elaborative interrogation and self-explanation overlaps with respect to implementation and cognitive mechanisms through which these strategies work.

There is considerable evidence for the cognitive benefits of explanations. Research suggests that explanatory questioning can facilitate learning and is effective across different contexts. For example, elaborative interrogation effects can be seen in learning conditions such as incidental or intentional learning instructions (Woloshyn, Willoughby, Wood, & Pressley, 1990), and among students working individually, in dyads, and in small groups (Woloshyn & Stockley, 1995). Students' characteristics such as high and low knowledge domains are explored in examining the effects of elaborative interrogation on learning outcomes as well. Woloshyn, Pressley, & Schneider (1992) presented Canadian and German students with facts about Canadian provinces and German states. The facts were facilitated by answering the questions such as "Why does that make sense given what you know about that particular province?"

tapping into the prior knowledge. Students in the study showed larger effects of elaborative interrogation in their high-knowledge domain than in their low-knowledge domain (Woloshyn et al., 1992).

Although most of the studies applied elaborative interrogation to discrete units of factual information, effects have also been shown in longer connected discourse (Dunlosky et al., 2013). Seifert (1994) found that elaborative interrogation significantly improved students' memory of facts contained in prose paragraphs. McDaniel and Donnelly (1996) examined the effectiveness of a variety of techniques—analogy, analogy with keyword highlighting, labeled pictorial schematics, and elaborative interrogation for enhancing newly acquired scientific concepts directly contrasting their relative effectiveness. The results showed that elaborative interrogation produced substantial learning gains both factual-level and inference-level performance. Table 2 outlines how elaborative interrogation prompts have been implemented in research studies.

Table 2

*Implementation of Elaborative Interrogation Prompts*

| Learning Context | Example of Prompts Used |
| --- | --- |
| Declarative knowledge about circulatory system (Chi, De Leeuw, Chiu, & Lavancher, 1994) | Why would the distribution of oxygen (a system wide function) be less efficient if there is a hole in the septum (a structure of the septum)? |
| Definitions of psychology terms (Hannon, 2012) | Identify the differences between the concepts. Generate an example. |
| Declarative knowledge about history of Japan (King, 1991) | In what ways is Japan related to other civilizations we learned? |
| Declarative knowledge of science concepts (McDaniel & Donnelly, 1996) | Why does an object speed up as its radius gets smaller? |
| Declarative knowledge of biology concepts (Seifert, 1994) | Why does the Richardson's ground squirrel live in underground tunnels? |
| Declarative knowledge of biology concepts (Willoughby & Wood, 1994) | Why would that animal do/have that? |

An important cognitive factor associated with the use of elaborative interrogation is that learners activate what Willoughby and Wood (1994) call "schemata" that help to organize new information that facilitates retrieval. The literature also points to learners being able to discriminate among related facts when identifying or retrieving newly learned information. This aspect is highlighted in Hannon's (2012) study, which distinguishes between integrative and comparative elaborations and argues that these variations seem to have different cognitive mechanisms. In integrative elaborations, for example, asking learners to generate how new themes or ideas in the text relate to one another may help activate and structure their conceptual knowledge. Similarly, in comparative elaborations, asking learners to compare pairs of examples which vary in quality facilitates the activation level of "critical distinctive" features in the memory trace of each concept making each memory trace more unique and complex (Hannon, 2012).

To summarize, there is a clear link between the cognitive mechanisms that promote learning based on prompting learners to explain their understanding and learning goals in a variety of different contexts. The strategy helps learners activate their cognitive processes of understanding by activating their prior knowledge, checking for gaps in their understanding, focusing on information that is new or unclear to them, and relating, organizing, and restructuring newly learned information (King, 1991; Palincsar & Brown, 1984; Willoughby & Wood, 1994; Willoughby, Wood, & Khan, 1994; Woloshyn et al., 1992). In the context of the present study, these mechanisms associated with the elaborative interrogation prompts are likely to promote synthesis of ideas in a number of ways—engaging their prior knowledge about the topic, noting gaps in their understanding, linking new ideas and themes from multiple sources, and structuring their conceptual understanding of the topic.

**Active-Constructive-Interactive Framework**

In the context of the present study, active-constructive-interactive framework provides a theoretical understanding and taxonomy of learners' activities and their corresponding cognitive processes (Chi, 2009). According to the framework, learners' activities may be divided in the three broad categories of active, constructive, and interactive. Active activities engage learners' attention at the most basic level (Chi, 2009). These activities include focusing on the learning material, repeating, or manipulating the learning material (Chi, 2009). Constructive activities involve learners producing outputs that generate new ideas through self-explaining, concept mapping, or hypothesis induction (Chi, 2009). Elaborative interrogation prompts being examined in this study fall under both active and constructive activities which drive the cognitive mechanisms that help learners map their prior knowledge, track their understanding, generate repair, and restructure new knowledge as they encounter multiple sources of information on a topic. Interactive activities, on the other hand, tend to engage learners through two kinds of dialogues: instructional dialogues and joint dialogues. Instructional dialogues may involve instructor guided activities such as scaffolding, adding revisions, and corrective feedback. Joint dialogues provide learners the opportunity to participate, build, and elaborate on a partner's contribution, argue and defend position (Chi, 2009). Table 3 on the following page summarizes the characteristics, overt activities, and cognitive processes in active, constructive, and interactive activities.

Table 3

*Active-Constructive-Interactive Framework with Characteristics, Overt Activities, and Cognitive Processes*

|  | **Active** | **Constructive** | **Interactive** |
|---|---|---|---|
| **Characteristics** | Doing something | Producing outputs that contain ideas that go beyond the presented information | Dialoguing acknowledging partner's contribution |
| **Overt activities** | Look, gaze, underline, paraphrase, select, repeat | Self-explain or elaborate, provide reasons, construct a concept map, self-monitor, connect, predict outcomes, generate hypothesis | Respond to scaffolding, revise errors, argue, defend, confront |
| **Cognitive processes** | *Attending Processes* | *Creating Processes* | *Jointly Creating Processes* |
|  | Activate existing knowledge assimilate, encode, or store new information, search existing knowledge | Infer new knowledge, integrate new information with existing knowledge, organize own knowledge for coherence, repair own faulty knowledge, restructure own knowledge | Creating processes that incorporate a partner's contributions |

*Note*: Adapted from Chi (2009).

Chi (2009) argues that activities such as self-explaining and elaborating engage learners to construct new ideas that go beyond the information presented in the learning material providing support for the hypothesis in this study that elaborative interrogation will improve not only integration but transformation of ideas in terms of elaborating on key themes presented in each source and adding other themes within and/or across sources. These activities, in turn, aid learners in inferring newly presented information, integrating it with their existing knowledge, and organizing and restructuring their knowledge. In other words, constructive activities such as

elaborations facilitate learners to not only analyze the content but also generate unique ideas. Another layer such as a dialogue, either with an expert or a peer, further facilitates learning, especially when dialogues contain substantive contributions from all partners in the conversation (Chi, 2009).

Based on the literature supporting the active-constructive-interactive framework, Chi (2009) claims that the set of activities that are active are more likely to engage learners than passive, activities that are constructive are more likely to enable the generation of new ideas than activities that are active, and activities that are interactive, i.e. involve instructional and joint dialogues, make more substantive contributions to learning than constructive activities (Chi, 2009). As Table 3 illustrates, the activities that activate learners' existing knowledge and help organize and structure new information, have the potential to significantly improve integration of information gathered from multiple sources of information. The next section reviews relevant literature in multiple document comprehension studies (Perfetti et al., 1999) to highlight how presentation of multiple documents along with writing prompts can aid comprehension and integration.

**Multiple Documents Comprehension**

Multiple documents comprehension studies focus on reading and comprehension of different text-based sources on the same topic or situation (Bråten & Strømsø, 2010). Research in multiple documents studies, which initially focused on summary and argument writing based on history tasks, indicates that argument writing tasks promote transformed, integrated, and causal constructions in student essays (Rouet et al., 1996; Wiley & Voss, 1999). Wiley and Voss (1999) presented students with multiple sources of information and asking why you think an event happened, as in argument condition, in contrast to asking how an event happened as in

explanation and summary condition produced more transformed and integrated constructions of the historical event. They concluded that multiple-source presentation facilitates building of mental models (Wiley & Voss, 1999).

The previous section on active-constructive-interactive framework and the multiple document studies reviewed for this section suggest that asking students to write arguments based on multiple sources of information facilitates constructive activity of integration of information that leads to better understanding. Furthermore, Wiley and Voss (1999) propose the possibility that argumentative writing prompts aid students in relating more pieces of information for the purpose of justification of their point of view. Gil, Bråten, Vidal-Abarca, & Strømsø (2010) found that students instructed to construct arguments from selected documents showed better comprehension and integration in their writing. Similarly, Le Bigot and Rouet (2007) found that students asked to write arguments based on texts about different aspects of social influence produced essays with more transformed information than students instructed to write summaries. It is, therefore, logical to assume that providing guided elaborative prompts to students as they encounter a variety of different sources of information on a topic may potentially increase integration and transformation of ideas.

The documents model proposed by Perfetti and colleagues (1999) highlights the mental representation that captures connections between and within documents as learners integrate and create their mental models about a topic. In addition, processes such as navigation, evaluation, reevaluation, and monitoring of how ideas connect within a text and across texts increases the need for employing metacognitive strategies and self-regulation skills (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012). In comparing the performance of better versus poorer learners, Goldman et al. (2012) found that better learners engaged in more sense-making, self-

explanation, and comprehension-monitoring processes than poorer learners and in turn performed better on measures such as inter-text connections, information evaluation, and produced essays that showed better integration of concepts. These findings accentuate the cognitive benefits that elaborative prompts provide in the context of integrating ideas from multiple documents.

Cognitive monitoring, therefore, brings processes of comprehension and integration of ideas to the surface and to the explicit attention of the learner. Employing strategies such as elaborative questioning and self-explaining are not only critical factors in text comprehension but also in terms of learning from multiple sources and constructing coherent and complete conceptual models about topics (Goldman et al., 2012; Graesser et al., 2007; Stadtler & Bromme, 2007; 2008). Based on these findings, Goldman et al. (2012) stress that there is a need to implement instructional models and design principles that include the use of metacognitive strategies to help learners develop an understanding of the complex interrelationships between multiple sources of information.

In another study, Stadtler and Bromme (2007) underscored the need for cognitive monitoring in comprehension of multiple documents as well as formation of document models (Perfetti et al., 1999). Comparing students who received evaluation prompts outperformed control group students in terms of knowledge about sources and produced more arguments relating to information sources. Previously, Stadtler and Bromme (2004) found that the use of metacognitive strategies correlated significantly with knowledge acquisition, suggesting that as learners acquire factual knowledge, the use of these strategies, in turn, facilitates more learning. These findings further emphasize that learners may generally be capable of executing these

strategies but as they encounter a new topic or encounter multiple sources of information, may not apply these strategies spontaneously (Stadtler & Bromme, 2007).

As evident from the focused review of these non-overlapping bodies of literature, including elaborative interrogation studies, active-constructive-interactive framework, and multiple documents comprehension studies, research evidence suggests that elaborative interrogation strategy offers significant cognitive benefits and provides metacognitive engagement with the learning material. A sizable body of research shows that prompting learners through elaborative interrogation has the potential to increase both integration and transformation of ideas (Dunlosky et al., 2013). However, most of the research has investigated the effect of elaborative interrogation in the context of procedural skills and factual statements. There has been limited research examining the effectiveness of the strategy on complex cognitive tasks. This study extends the literature by investigating whether complex, higher-order cognitive tasks such as integration and transformation of ideas can be enhanced by incorporating elaborative interrogation prompts in multiple sources of information.

**Chapter III**

**Methodology**

The goal of this study was to test the effectiveness of elaborative interrogation prompts on integration and transformation of ideas gathered from multiple sources of information on a topic. Consistent with the prior research using elaborative prompts (Dunlosky et al., 2013), the theoretical assumption guiding this study is that students responding to elaborative interrogation prompts will have increased awareness of their understanding of texts as they encounter new information about the topic and will connect their prior knowledge to new information during this process. Therefore, it was hypothesized that participants who receive embedded elaborative prompts would perform significantly better on both integration and transformation measures.

**Participants**

The participants were recruited using Amazon's Mechanical Turk (AMT). Started in 2005, AMT provides a crowdsourcing web service platform that allows businesses to distribute tasks to an anonymous workforce (Schulze, Seedorf, Geiger, Kaufmann, & Schader, 2011). The service can also be used to recruit participants for research studies involving surveys and experiments in exchange for small wages. The platform allows researchers to set predefined criteria to recruit subjects (workers) to perform these Human Intelligence Tasks (HITs) (Paolacci, Chandler, & et al., 2010). One hundred and twenty slots were created for the experiment—40 for each condition of the experiment. The researcher set the recruitment criteria to include participants from the United States only along with a prior task approval rating of at least 70%. The prior approval rate allows requesters to recruit workers who have successfully completed HITs in the past. For example, if a worker has completed 100 HITs and had their work rejected 5 times, their approval rate is 95%.

Bartneck, Duenser, Moltchanova, & Zawieska (2015) address the concerns regarding the representativeness of AMT samples and data quality stating that samples drawn from population of U.S. workers which constitutes a majority of AMT workers, are comparable to samples drawn from other research pools. In evaluating the potential for psychology and other social science research, Buhrmester, Kwang, & Gosling (2011) suggest that the results may be often more generalizable than results from samples recruited through traditional methods.

As with any human participant research, participants were informed of the nature and complexity of the task, researcher's expectations, compensation, privacy rights, an easy to read consent statement, as well as notification of academic not-for-profit research study. In addition, the researcher notified participants of limitations regarding use of data other than research associated with using AMT as a platform for data collection (Kent State University, 2018). The experimental task was designed in Qualtrics as three surveys representing each experimental condition. Qualtrics is an online software that enables researchers to design, distribute, and analyze survey data (Qualtrics, 2017)—and implanted in AMT as a URL link. Each survey link was embedded in AMT as a task representing each condition of the experiment. The participants completed only one of the three embedded tasks in AMT. Once a participant completed the required task, an AMT code was generated and sent to the AMT platform to notify the researcher that the participant had completed the assigned task.

**Conditions**

Participants were given instructions in each of the three conditions about the topic and were instructed to read the five texts (see Appendix B for surveys for each experimental condition), respond to elaborative prompts (treatment conditions only), and then write a paragraph that synthesizes the information (all three conditions). Three conditions were as follows:

1. Elaborative interrogation prompts (EP-treatment group): Participants in this condition typed their responses to elaborative interrogation prompts that are embedded after each individual text.

2. Elaborative interrogation prompts with reverse order of texts (EP-RO-treatment group): Participants in this condition typed their responses to elaborative interrogation prompts that are embedded after each individual text presented in reverse order to minimize order effects bias (Whitley & Kite, 2013).

3. No elaborative interrogation prompts (C-control group): Participants in this group read the provided texts with no prompts.

**Selection of Topic and Information Sources**

For the purpose of achieving ecological validity (Whitley & Kite, 2013) in operationalizing the design of the study, it was important to choose a topic at the comprehension level of freshmen undergraduate students, and is not domain specific. The choice of topic and scenario also needed to take into account that the provided texts represented a variety of formats (e.g., article, industry report, research report) so as to not privilege one type of information source, and each contributing unique ideas to the topic. Presenting a finite set of pre-selected materials allowed for experimental control over the content as well as facilitated identifying idea units in the synthesis paragraph. Similarly, for ensuring content validity (Whitley & Kite, 2013), participants needed to understand the nature and scope of the topic before they read the provided texts. Therefore, the description and instructions (Appendix B) were constructed to guide students in synthesizing their ideas from the sources.

Information sources on the topic of climate change were used with permission from a multiple documents comprehension study conducted by Strømsø, Bråten, & Britt (2010). The

topic was chosen because it lent itself to constructing an argument. The sources were chosen to develop an understanding of the topic. Similarly, short descriptions of these sources were written summarizing key ideas. To minimize fatigue effects (Gil et al., 2010; Whitley & Kite, 2013), the length of the summaries for each source was kept to a minimum. The readability (Björnsson 1968) of these summarized sources was another methodological concern (Gil et al., 2010). Strømsø et al. (2010) addressed this concern by ensuring that the summarized sources were at the level of a standard college text in terms of readability. Table 4 briefly describes each source.

Table 4

*Description of Information Sources on Climate Change*

| Text Source | Description | Word Count |
|---|---|---|
| **Text 1:** Textbook | Explains the natural greenhouse effect and the manmade greenhouse effect in relatively neutral, academic terms | 362 |
| **Text 2:** Center for International Climate and Environmental Research at the University of Oslo | Focuses on the causes of the manmade greenhouse effect, that is, on the manmade discharges of climate gases into the atmosphere and their contribution to observed climate changes | 251 |
| **Text 3:** Popular science article | Argues that climate changes to a large extent are steered by astronomical conditions and therefore due to natural causes rather than mankind's activities | 277 |
| **Text 4:** Newspaper article | Describes the negative consequences of global warming in terms of a potential weakening of ocean currents in the North Atlantic and a melting of ice around the poles | 302 |
| **Text 5:** Newspaper article | Describes the positive consequences of a warmer climate in northerly regions in terms of an ice-free sea route through the Northwest Passage and the access to natural resources now concealed under the Arctic ice | 231 |

*Note:* Adapted from Strømsø et al. (2010).

**Procedure**

The task was made available to the participants in AMT as "learning about climate change" for each of the experimental conditions. The researcher provided the description, keywords, compensation, and maximum number of assignments (participants) in each of the conditions. Once the task was accepted, the participants clicked on the embedded Qualtrics survey link in AMT. The experimental procedure in Qualtrics is described in Table 5 below, highlighting the cognitive functions associated with each step.

Table 5

*Description of Steps in the Procedure*

| Steps | Description | Function |
|---|---|---|
| 1. Topic Introduction | Introduction to the task and topic description (Appendix B) | Introduces the topic and task to the participants |
| 2. First Set of Elaborative Interrogation Prompts (1.1 and 1.2 Treatment Group) | 1.1 "What do you already know about the topic?" 1.2 "What questions come to your mind after you have read the topic description?" 1.3 "On a scale of 1-10, (1 representing least interest, and 10 representing most interest), how interested are you in the topic of climate change?" (1.1 and 1.2 for treatment group only and 1.3 for both groups) | Engages prior knowledge of the topic. Level of interest serves as a covariate |
| 3. Presentation of Texts | The five texts were introduced as "Text 1" "Text 2" etc. without any descriptors. | Develops participants' understanding of the key issues and concepts associated with climate change |
| 4. Second Set of Elaborative Interrogation Prompts (Treatment Group) | 2.1 "As you examine this source, what new themes emerge about the topic?" "How are these themes related to what you read in other sources?" (Second prompt embedded in second and subsequent texts) | Drives paraphrase, elaboration, and addition cognitive mechanisms |
| 5. Synthesis Essay | Participants in all groups composed their synthesis paragraphs after reading the texts. | Synthesis essay coded for measures of transformation and integration measures (Table 6) |

On successful completion of the task, an AMT code was generated in Qualtrics that participants copied in their AMT workers' account, prompting the researcher to compensate the participants.

**Independent and Dependent Measures**

The methodology of this study is in line with previous studies that followed similar procedures using idea units, argumentative units, and core arguments as tools for measuring comprehension (Chi et al., 1994; Coté, Goldman, & Saul, 1998; Rouet et al., 1996; Wiley & Voss, 1999; Wolfe & Goldman, 2005). The researcher adapted the coding scheme for the various dependent measures based on Gil et al. (2010) which examined summary and argumentative tasks in the context of working with multiple documents. The coding scheme consists of two main categories: transformation and integration. Transformation includes the sub-categories paraphrase, elaboration, addition, and misconception; and integration includes the sub-category number of texts and number of switches between sources. Operational definitions of these categories are described in Table 6 on the following page.

Table 6

*Operational Definitions of the Writing Measures*

| Main Category | Sub-category | Description |
|---|---|---|
| **Transformation (P + E + A - M)** | Paraphrase (P) | Student states text content in their own words without changing meanings expressed in the source material |
| | Elaboration (E) | Student uses source material in combination with information from prior knowledge or combines two or more pieces of information within or across texts |
| | Addition (A) | Student includes related information from prior knowledge or states personal opinion about the topic |
| | Misconception (M) | Student includes statements indicating misunderstanding of the content of the source material |
| **Integration (T + S)** | Number of texts (T) | Number of different sources used |
| | Number of switches (S) | Number of switches between sources |

*Note:* Adapted from Gil et al. (2010).

**Exclusion Criteria**

The results from treatment conditions that did not include responses to the elaborative prompts after each text were excluded from the analysis. Similarly, results that contained meaningless words and symbols in either replies to elaborative prompts or the synthesis task were excluded from analysis. As per task instructions, the participants were asked to write their report based on the provided texts; therefore, the responses that contained irrelevant content not related to climate change were also excluded.

**Coding Synthesis Paragraphs**

In tasks that require learners to write arguments or summaries from multiple sources (Chi et al., 1994; Coté et al., 1998; Rouet et al., 1996; Wiley & Voss, 1999; Wolfe & Goldman, 2005), student essays are segmented into idea units, often at the sentence level, containing one or more related items of information. As prescribed by the original coding scheme (Gil et al., 2010), each idea unit was coded as representing one of four types of transformation of the original text—either paraphrase, elaboration, addition, or misconception to calculate the overall transformation score.

Idea units were coded as paraphrases if the respondents used their own words without changing the meaning expressed in the text. For example, *"The increase in the release of carbon dioxide into the atmosphere has caused an increase in the temperature of the earth."* Idea units were coded as elaborations if they contained information from the text in combination with some information from prior knowledge or if they combined two or more pieces of information either within or across texts, which were not connected in the source. For example, "*The warming of the climate causes farming and forestry to become affected, as extreme warming can lead to extreme cold spells causing crop damages that hurt local populations and wildlife."* Idea units were coded as additions if they contained only related information from prior knowledge or personal opinions about climate change. For example, *"The increasing use of fossil fuels has to be stopped, as if we don't, we will continue to experience harsh consequences (these hurricanes, Harvey and Irma) as a result of our continued ignorance and unwillingness to refute fossil fuels."* Idea units were coded as misconceptions if they contained false statements or misunderstanding in relation to the information in the original texts. For example, *"The global*

*average temperature today is about 15C, though geological evidence suggests it has been much*

*higher and lower in the past."*

In terms of integration, the goal was to identify the text with each idea unit in the synthesis paragraphs and count the number of different texts that the respondent used in their writing. For example, a score of five suggests that the response included all five texts and a score of zero suggests a lack of coverage of original texts. In addition, the number of switches between texts were counted. For example, if a response contained ten idea units and the first three idea units came from text 1, the next five came from text 2, and the last two came from text 3, it was counted as two switches. The aggregate score for the integration measure was calculated by adding the number of texts used and number of switches between texts.

A random subset of 20 responses, which accounted for over 20% of the total after excluding responses based on the exclusion criteria described previously, were coded independently by the researcher and one experienced writing instructor using the coding scheme described in Table 6, resulting in the overall interrater agreement of 74% for the transformation measure and 89% for the integration measure. All disagreements in coding were discussed between the two rates to gain more insight into interpretation of the coding scheme. Once agreement was established, the researcher coded the entire remaining data set.

The number for each sub-category measure such as paraphrases, elaborations, additions, and misconceptions were calculated along with the number of total words and sentences in the synthesis paragraphs. After the synthesis essays were coded, an aggregate score for each condition for both transformation and integration measures were calculated and the resulting data set was used to perform descriptive and inferential analysis presented in the following chapter using the Statistical Package for the Social Sciences (IBM, 2017).

**Chapter IV**

**Results**

The purpose of the present research investigation was to evaluate the effect of elaborative interrogation instructional strategy on the synthesis of ideas from multiple sources of information. To this aim, 86 participants, recruited via Amazon's Mechanical Turk, were asked to read five texts on climate change and write a paragraph that synthesized the information. Participants were randomly assigned to one of three conditions. The first condition involved the presentation of elaborative interrogation prompts after each individual text (EP-treatment group), while the second condition included the incorporation of elaborative interrogation prompts after each individual text presented in reverse order (EP-RO-treatment group). Finally, the third condition involved only the presentation of texts, without any elaborative interrogation prompts (C-control group).

Participants were assessed on two categories, namely transformation and integration. Transformation included the sub-categories paraphrase, elaboration, addition, and misconception, while integration involved the subcategories, number of texts used, and number of switches between sources. Two aggregate scores were calculated for each category, with higher values being indicative of higher performance in transformation and integration measures. The number of words and sentences produced in each condition was also measured and the prior interest of participants in climate change was assessed to account for potential confounders. Lastly, demographic information about the age, gender, and educational level of participants was collected.

Two directional hypotheses were formulated and appropriate inferential analyses were employed for their empirical examination. First, it was hypothesized that the presentation of

elaborative interrogation prompts will have a statistically significant effect on the transformation performance of participants. Particularly, it was assumed that individuals who received elaborative interrogation prompts would report higher transformation scores, as compared to participants who did not (Hypothesis 1). The second hypothesis postulated that the presentation of elaborative interrogation prompts would exert a statistically significant influence on the integration performance of participants. Specifically, it was expected that individuals who received elaborative interrogation prompts would report higher integration scores, in comparison to participants who did not (Hypothesis 2). It was also speculated that the prior interest of participants in climate change, as well as their educational level, would impact their transformation and integration performance. In order to address a potential confounding effect, prior interest in climate change and educational level were treated as covariates in the relevant statistical model. Taking into consideration the above hypotheses, the researcher employed 2 one-way analyses of covariance (ANCOVAs) to assess the effect of elaborative interrogation prompts on transformation and integration outcomes, while controlling for a potential confounding effect of pre-existing interest in climate change and educational level.

A comprehensive examination of the available data was conducted to ensure the accuracy of subsequent conclusions. Initially, a descriptive analysis was performed to identify the demographic characteristics of the sample, assess the number of participants and distribution of demographics among conditions, and gain a preliminary insight into the performance of participants, independently of condition. Afterwards, the assumptions of one-way ANCOVA were evaluated. Finally, the findings of the respective inferential analyses were presented in-detail.

**Sample Characteristics**

Prior to the assessment of research hypotheses, it is essential to identify the characteristics of the sample, in order to evaluate the representativeness and quality of data. Regarding the demographic characteristics of the sample, an almost equal distribution of men (52%) and women (46%) was observed, while half of the participants (51%) were aged between 25-34 years. In reference to education, almost half of the respondents held a Bachelor's degree (45%), followed by those earned some college credit (28%) (Table 7).

Table 7

*Demographic Characteristics of the Sample*

| Gender | % |
|---|---|
| Women | 46% |
| Men | 52% |
| Other | 2% |
| **Age** | |
| 18-24 years | 7% |
| 25-34 years | 51% |
| 35-44 years | 28% |
| 45+ years | 14% |
| **Education** | |
| High school graduate, diploma or the equivalent | 6% |
| Some college credit, no degree | 28% |
| Associate degree | 12% |
| Bachelor's degree | 45% |
| Master's/doctorate degree | 9% |

The second step involved the evaluation of the number of participants and distribution of demographics among conditions. A frequency analysis indicated an almost equal distribution of participants among conditions (Figure 1).
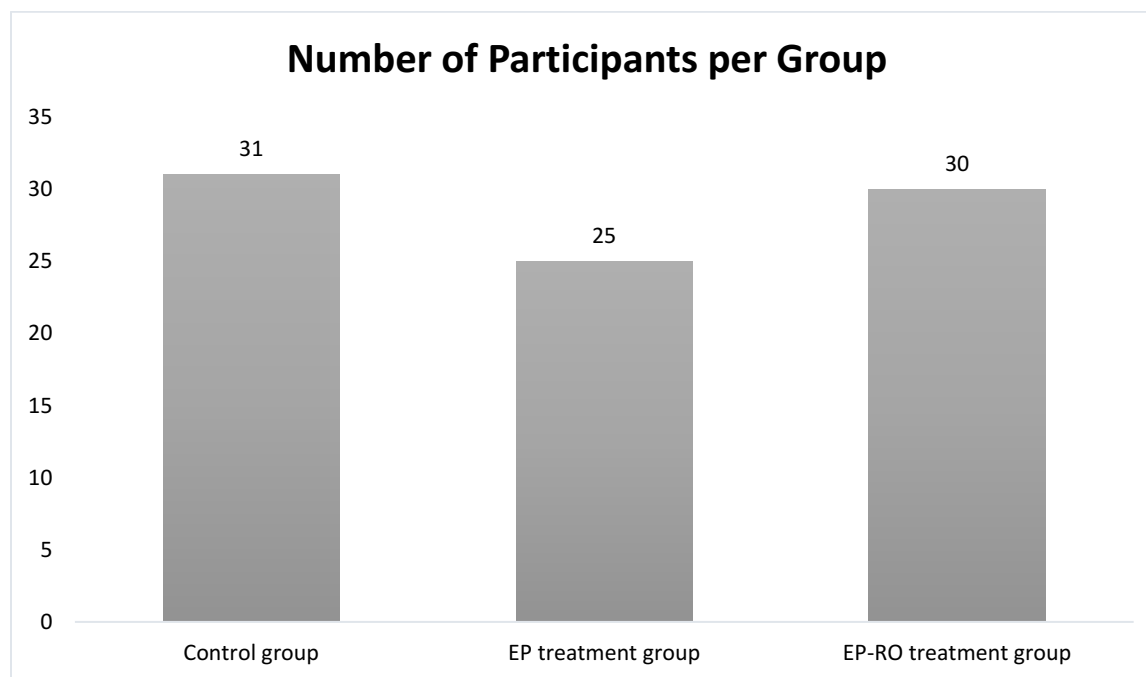


*Figure 1*. Number of participants per group.

Furthermore, a satisfactory distribution of age cohorts and educational levels among conditions was observed, although it should be noted that the EP treatment group did not include any individuals aged 45 years or older (Tables 8 and 9).

Table 8

*Distribution (n) of Age Cohorts Among Conditions*

| | Age Cohort (years) | | | |
|---|---|---|---|---|
| Condition | 18-24 | 25-34 | 35-44 | 45+ |
| Control | 2 | 16 | 8 | 5 |
| EP-treatment | 3 | 16 | 6 | 0 |
| EP-RO treatment | 1 | 12 | 10 | 7 |

Table 9

*Distribution (n) of Educational Levels Among Conditions*

| | | | Educational Level | | |
|---|---|---|---|---|---|
| Condition | High-school | Some college | Associate degree | Bachelor's degree | Master's/Doctorate degree |
| Control | 3 | 9 | 4 | 11 | 4 |
| EP-treatment | 1 | 7 | 3 | 12 | 2 |
| EP-RO-treatment | 1 | 8 | 3 | 16 | 2 |

However, a highly unequal distribution of men and women among conditions was revealed, as the control group involved an overrepresentation of men and the EP-RO treatment group an overrepresentation of women (Table 10).

Table 10

*Distribution (n) of Gender Among Conditions*

| | | Gender | |
|---|---|---|---|
| Condition | Women | Men | Other |
| Control | 8 | 20 | 2 |
| EP-treatment | 12 | 13 | 0 |
| EP-RO-treatment | 19 | 11 | 0 |

The last step of preliminary analyses included the calculation of descriptive statistics for the performance of participants, independent of condition, as assessed by 10 variables. The objective of this analysis was twofold. First, the identification of minimum and maximum values for each variable facilitated the interpretation of subsequent descriptive and inferential analyses. Secondly, and most importantly, the calculation of means and standard deviations allowed the researcher to assess the variation of scores, which is especially desirable in experimental research designs (Pallant, 2016). As shown in the following table, high standard deviations were observed

in all variables, suggesting that mean values are dependent on certain factors; hopefully on the introduction of elaborative interrogation prompts (Table 11).

Table 11

*Descriptive Analysis on Variables Assessing Transformation and Integration Performance*

|  | Minimum | Maximum | M | SD |
|---|---|---|---|---|
| N of words | 30 | 625 | 141.59 | 85.71 |
| N of sentences | 2 | 17 | 7.31 | 3.45 |
| N of paraphrases | 0 | 14 | 2.58 | 3.32 |
| N of elaborations | 0 | 12 | 1.92 | 2.29 |
| N of additions | 0 | 12 | 2.73 | 2.72 |
| N of misconceptions | 0 | 1 | .06 | .24 |
| N of texts | 0 | 5 | 2.81 | 1.39 |
| N of switches | 0 | 7 | 2.07 | 1.49 |
| Overall transformation score | 2 | 17 | 7.26 | 3.49 |
| Overall integration score | 0 | 12 | 4.88 | 2.82 |

**Assumption Testing**

The next analytical stage involved the assessment of the 10 assumptions required for one-way ANCOVA. One-way ANCOVA is a parametric test and thus, compliance with certain assumptions is critical to the accuracy of findings (Field, 2013). The first four assumptions relate to the research design of the study and require a continuous dependent variable, categorical independent variable, continuous covariate(s), as well as independence of observations. The other six prerequisites evaluate the quality of data and assume linearity, homogeneity of

regression slopes, normally distributed residuals, homoscedasticity, homogeneity of variances, and absence of outliers (Field, 2013).

However, prior to the assessment of the above prerequisites, an assumption pertinent to the specific research design should be examined. The two covariates were included in the selected statistical model and therefore, the relationship between them should be inspected for issues of multicollinearity (Pallant, 2016). A Pearson's correlation analysis between prior interest in climate change and educational level indicated a non-statistically significant very *weak* relationship, $r$ (84) = .051, $p$ = .64 (two-tailed). Therefore, multicollinearity was not a concern and the researcher proceeded with the investigation of the assumptions. Results are presented separately for hypothesis 1 and hypothesis 2 to ensure the legibility of the section.

**Hypothesis 1.** Hypothesis 1 assessed the effect of elaborative interrogation prompts on the transformation performance of participants, while controlling for a potential effect of interest in climate change and educational level. Transformation, the dependent variable, was measured at a continuous level (value range, 2-17) and so were the covariates, interest in climate change (value range, 1-10), and educational level (value range, 1-6). In contrast, the independent variable was measured at a nominal level and included three groups, namely control group, EP-treatment group, and EP-RO treatment group. The experimental manipulation of the independent variable also ensured independence of observations, as participants were assigned to only one of three conditions.

Regarding data quality, the visual inspection of grouped scatterplots indicated a linear relationship between interest in climate change and transformation, as well as between educational level and transformation, for each condition. An analysis of variance also suggested homogeneity of regression slopes, as a non-statistically significant interaction term between

condition and interest in climate change, $F(2, 77) = .22$, $p = .81$, as well as between condition

and educational level, $F(2, 77) = 1.06$, $p = .35$, was observed. Furthermore, homoscedasticity

and homogeneity of variances was present, as evaluated by a scatterplot of standardized residuals

against predicted values and Levene's test of equality of error variances ($p = .40$), respectively.

Finally, a normal Q-Q plot displayed approximately normally distributed residuals and an

absence of outliers was indicated, as all standardized residuals were less than $\pm 3$ standard

deviations (Field, 2013).

    **Hypothesis 2.** Hypothesis 2 investigated the effect of elaborative interrogation prompts

on the integration performance of participants, while controlling for a potential effect of interest

in climate change and educational level. Integration, the dependent variable, was measured at a

continuous level (value range, 0-12) and so were the covariates, interest in climate change (value

range, 1-10) and educational level (value range, 1-6). On the contrary, the independent variable

was measured at a nominal level and included three groups: the control group, the EP-treatment

group, and the EP-RO treatment group. The experimental manipulation of the independent

variable also ensured independence of observations, as participants were assigned to only one of

three conditions.

    In reference to data quality, the visual inspection of grouped scatterplots indicated a

linear relationship between interest in climate change and integration, as well as between

educational level and integration, for each condition. An analysis of variance also suggested

homogeneity of regression slopes, as a non-statistically significant interaction between condition

and interest in climate change, $F(2, 77) = .82$, $p = .44$, as well as between condition and

educational level, $F(2, 77) = .60$, $p = .55$, was observed. Furthermore, Levene's test of equality

of error variances indicated homogeneity of variances ($p = .75$), but a scatterplot of standardized

residuals against predicted values was suggestive of a slight 'funnel' pattern. However,

ANCOVA is fairly robust to violations of assumptions and therefore, there was no reason for

serious concern (Field, 2013). Lastly, a normal Q-Q plot displayed normally distributed residuals

and an absence of outliers was indicated, as all standardized residuals were less than $\pm 3$ standard

deviations (Field, 2013).

**Assessment of Hypotheses**

Taking into account that the examination of the one-way ANCOVA assumptions

revealed a satisfactory data quality, the assessment of research hypotheses followed. A

combination of descriptive and inferential analyses was employed to thoroughly evaluate the

hypotheses under investigation and differences among conditions were highlighted by the

incorporation of visual aids. The findings for each hypothesis are presented in separate sections

to enhance readability.

**Hypothesis 1.** In order to explore if there is a statistically significant effect of elaborative

interrogation prompts on transformation performance, while controlling for a potential effect of

prior interest in climate change and educational level, a one-way ANCOVA was conducted.

Contrary to the expectations of the researcher, an initial descriptive analysis showed that control

group performed slightly better than treatment groups, whereas EP-RO treatment group reported

the lowest mean transformation scores (Figure 2 on the following page).

*Figure 2*. Mean differences in transformation performance among groups.

After adjusting for interest in climate change and educational level, a one-way ANCOVA indicated a non-statistically significant effect of condition on transformation outcomes, $F$ (2, 81) = .39, $p$ = .67, $\eta_p^2$ = .010, with the same pattern of mean differences being observed (Table 12).

Table 12

*Unadjusted Condition Means (M) and Standard Deviations (SD) and Adjusted Condition Means (M) and Standard Errors (SE) for Transformation Performance with Interest in Climate Change and Educational Level as Covariates*

|  |  | Unadjusted |  | Adjusted |  |
| --- | --- | --- | --- | --- | --- |
|  | *n* | *M* | *SD* | *M* | *SE* |
| Control condition | 31 | 7.55 | 3.56 | 7.67 | .62 |
| EP-treatment condition | 25 | 7.24 | 3.89 | 7.06 | .69 |
| EP-RO treatment condition | 30 | 6.97 | 3.15 | 6.97 | .62 |

In reference to the relationship of covariates with transformation performance, results revealed a statistically significant relationship between interest in climate change and transformation, $F(1, 81) = 5.27$, $p = .024$, $\eta_p^2 = .061$, suggesting that higher levels of interest in climate change are related to higher transformation performance. Nevertheless, the small effect size reported is indicative of a rather weak relationship. Lastly, a non-statistically significant relationship between educational level and transformation, $F(1, 81) = 1.78$, $p = .19$, $\eta_p^2 = .021$, was observed.

To summarize the primary findings, a descriptive analysis showed that participants in control group achieved a slightly better performance in transformation, as compared to participants in treatment groups. In addition, a one-way ANCOVA indicated that the presentation of elaborative interrogation prompts did not exert a significant amount of influence on transformation measure. Therefore, hypothesis 1 is not supported.

**Hypothesis 2.** In order to explore if there is a statistically significant effect of elaborative interrogation prompts on integration performance, while accounting for a potential effect of interest in climate change and educational level, a one-way ANCOVA was conducted. In accordance with the expectations of the researcher, a preliminary descriptive analysis showed that treatment groups performed better than control group and EP-RO treatment group reported the highest integration scores (Figure 3 on the following page).
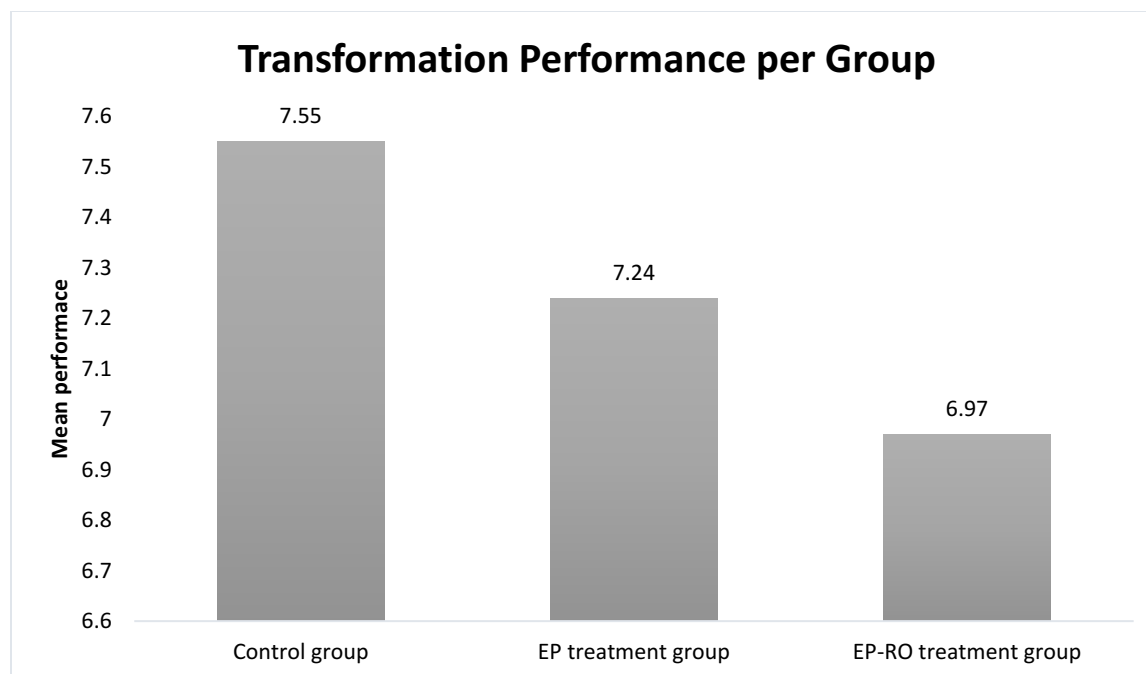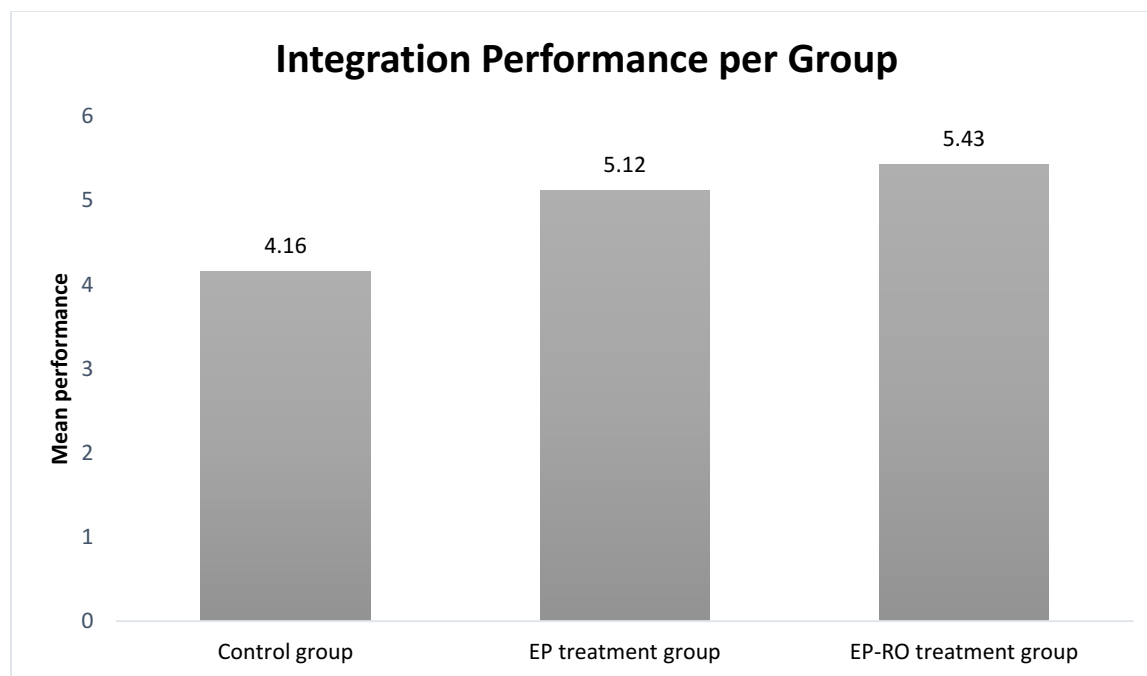
*Figure 3*. Mean differences in integration performance among groups.

After adjusting for interest in climate change and educational level, a one-way ANCOVA indicated a non-statistically significant effect of condition on integration outcomes, $F(2, 81) = 1.43$, $p = .25$, $\eta_p^2 = .034$, with the same pattern of mean differences being observed (Table 13).

Table 13

*Unadjusted Condition Means (M) and Standard Deviations (SD) and Adjusted Condition Means (M) and Standard Errors (SE) for Integration Performance with Interest in Climate Change and Educational Level as Covariates*

|  | | Unadjusted | | Adjusted | |
|---|---|---|---|---|---|
|  | *n* | *M* | *SD* | *M* | *SE* |
| Control condition | 31 | 4.16 | 2.51 | 4.23 | .50 |
| EP-treatment condition | 25 | 5.12 | 2.96 | 5.09 | .56 |
| EP-RO treatment condition | 30 | 5.43 | 2.94 | 5.39 | .51 |

Concerning the relationship of covariates with integration performance, a non-statistically significant relationship between pre-existing interest in climate change and integration, $F(1, 81) = .027$, $p = .87$, $\eta_p^2 < .001$, was observed. However, results revealed a statistically significant relationship between educational level and integration, $F(1, 81) = 4.31$, $p = .041$, $\eta_p^2 = .051$, denoting that higher levels of education are related to higher integration performance. Nevertheless, a small effect size was reported, which is indicative of a rather weak relationship.

Conclusively, a descriptive analysis showed that participants in treatment conditions achieved a better performance in integration than participants in control group. Nevertheless, a one-way ANCOVA revealed that the presentation of elaborative interrogation prompts did not significantly impact integration measure. Therefore, hypothesis 2 is not supported. The results are discussed in the following chapter.

**Chapter V**

**Discussion**

**Summary**

This study examined the effectiveness of elaborative interrogation prompts on integration and transformation of ideas from multiple sources of information on the topic of climate change. Acknowledging the need for evidence-based information literacy instruction for the new Framework for Information Literacy for Higher Education, the researcher examined the frame "Research as Inquiry" which includes the "ability to synthesize ideas gathered from multiple sources" as one of its associated knowledge practices.

The focused review of the literature included elaborative interrogation studies and multiple documents comprehension studies which suggested that elaborative interrogation strategy offers significant cognitive benefits and provides metacognitive engagement with the learning material. Most of the prior research investigated the effect of elaborative interrogation in the context of procedural skills and factual statements. Acknowledging this gap in the literature and using active-constructive-interactive framework as a theoretical grounding for the study, it was hypothesized that prompting learners through elaborative interrogation will significantly improve integration and transformation measures in terms of synthesis of ideas from multiple sources of information on the topic of climate change.

To this end, the researcher recruited 86 participants using Amazon Mechanical Turk platform and embedded experimental task using an online survey platform. Contrary to the research hypothesis, the results of the descriptive analysis showed that participants in the control group achieved a slightly better performance in the transformation measure, as compared to participants in treatment groups. For the integration measure, a preliminary descriptive analysis

showed that the treatment groups performed better than the control group. However, two one-way ANCOVAs were employed to test the hypotheses which indicated that elaborative interrogation prompts did not exert a significant amount of influence on transformation and integration measures. Therefore, hypotheses 1 and 2 were not supported.

Contrary to what was hypothesized, the results from the descriptive analysis showed that the participants' performance was slightly better on transformation measure in the control group. A logical explanation of this could be the extra time and cognitive effort spent in both treatment groups (EI and EI-RO) to respond to the prompts after each text compared to no prompts in the control group, thereby giving participants more time to write the synthesis paragraphs. Responding to prompts after each text could have been perceived as cognitively taxing. In light of prior work in multiple documents literacy (Gil et al., 2010), this may also reflect that the cognitive mechanisms that scaffold learners' ability to study multiple information sources to construct and present arguments on a topic are complex and require a more sustained and distributed effort. The following section acknowledges this and other limitations of the research.

**Limitations**

With respect to developing a conceptual understanding of a topic from multiple documents (Perfetti et al., 1999), one of the limitations of this design is that it represents only one of many ways of presenting multiple texts to gather information and synthesize ideas, thus limiting the ecological validity of the study (Whitley & Kite, 2013). There are a variety of platforms and manifestations, both print and digital, that participants may have been more used to when using multiple sources of information on a given topic.

As Dunlosky et al. (2013) point out, the majority of studies examining the effectiveness of elaborative interrogation strategy have focused on measures such as recall, memory for facts,

memory for main ideas, and free-recall tests. Few studies have examined the use of the strategy in the context of comprehension or the application of the factual information. The higher-level transformation and integration tasks using multiple sources are more cognitively demanding than the array of fact recall tests from a single document that have previously been the focus of research.

Another limitation associated with using AMT for participant recruitment is low financial reward (Goldman et al., 2012). The primary motivation of the participants is to complete the required task in order to get compensated. It is difficult to pay sustained attention to a task involving a variety of increasingly cognitively demanding steps that include reading, reflecting, and writing based on the provided content—embedded in an online survey platform in a short period of time as noted in the discussion of results in the previous section. Higher-order cognitive tasks such as integration and transformation of ideas investigated in this study demand considerably higher level of sustained engagement, focus, and concentration compared to other tasks such as taking part in short surveys and questionnaires.

Similarly, Buhrmester et al. (2011) note that another limitation to AMT is the lack of opportunity to exert control over participants' environment compared to lab studies. Controlling for time taken to complete the assigned sub-tasks such as time spent on each text and time allocated for writing the synthesis paragraph were beyond the researcher's control in the present study.

The topic of climate change was well-suited for the study as it lends itself to writing a short synthesis piece. The presentation of scientific information has been demonstrated to facilitate conceptual change (Ranney & Clark, 2015). However, climate change is also a politically charged topic and despite the researcher's attempt to select the texts from a previous

research study, the possibility that participants may have selectively focused on texts that contained information that they considered most important or reflected their prior understanding or stance on the topic is still a concern.

**Implications for Practice and Future Research**

The present study contributes to the growing body of literature on the new Framework, its associated knowledge practices, and ways to develop pedagogical and assessment approaches. In addition, the study contributes to the literature on multiple documents literacy, effective learning techniques, and application of active-constructive-interactive framework. As noted previously in the limitations section, the study focused on short sources of information on the topic of climate change, further research is needed to examine the effect of elaborative prompts under different tasks and topics that involve comprehension, integration, and transformation other than climate change. Using texts and coding scheme from prior research studies in multiple documents comprehension helped provide experimental control in terms of research design. However, starting from scratch with another topic would involve selecting texts, reading and identifying key idea units within each text, and creating similar coding schemas might prove to be daunting tasks from the practitioners' standpoint. Conversely, developing an assessment based on a similar coding scheme might provide a more robust measure of synthesis than a generalized rubric-based assessment (Oakleaf, 2008).

Second, the individual amount of time spent on each text was not measured in this study. The research assumes that participants spent roughly the same amount of time on each text. Future research needs to examine and control for this important variable in assessing overall integration and transformation. The researcher believes that triangulating the assessment of

synthesis with other methods such as think-aloud, screencasts, eye-tracking, and other log data measures would further develop this line of research.

Lastly, as prior research on multiple documents comprehension illustrates, the cognitive processes that scaffold the synthesis of ideas are not well understood (Rouet, 2006). It presents unique challenges for researchers especially in terms of acknowledging the familiarity with the platform, format, medium of presentation of documents, prior knowledge, level of interest, as well as imposed vs. self-generated inquiry. The degree to which the effect of elaborative interrogation technique generalizes to these variables and their interactions need to be further examined. Assessment of a shape-shifting ghost such as synthesis of ideas from multiple documents is full of contextual factors that determine how learners interact with and gather information from an increasingly complex information landscape. Considering these limitations, the researcher believes that future research needs to draw from other non-overlapping bodies of literature that provide both theoretical grounding and refine research methods to examine this problem more holistically.

**Conclusion**

The primary motivation for the researcher to embark on this project was to examine and align one of the key knowledge practices in the new Framework—the ability to synthesize ideas gathered from multiple sources of information with an appropriate learning technique— elaborative interrogation. As stated in the rationale for the study and brief overview of the Framework, these individual frames highlight the threshold concepts learners experience as they navigate a complex, uncertain, and evolving information ecosystem. The shift from previous skill-based, mechanistic standards has amplified the need to draw tangential connections with cognitive and learning science principles and advance new ways to effectively develop

curriculum for information literacy and assess learners' performance as they improve their understanding of these knowledge practices and navigate these threshold concepts. The interconnected threshold concepts in the Framework represent a move away from prescriptive outcomes and skills, and the nebulous and abstract nature of these concepts presents challenges for both practitioners and researchers. The synergy between research and practice is what is urgently needed in the profession—a long-term research-practice collaboration that provides practitioners a theoretical grounding for the praxis of information literacy instruction.

Just as the Framework represents a renewed approach to conceptualizing information literacy, this line of research represents a new focus on aligning effective learning and assessment techniques, acknowledging behavioral, affective, cognitive, and metacognitive dimensions of learning. The introduction of the Framework has prompted the much needed dialogue between research and practice to examine the theoretical assumptions of teaching and learning and it is the researcher's hope that this work will further engage colleagues from both sides to develop evidence-based recommendations for information literacy instruction.

Appendix A

Association of College & Research Libraries Framework

for Information Literacy for Higher Education

## Authority Is Constructed and Contextual

**Information resources reflect their creators' expertise and credibility and are evaluated based on the information need and the context in which the information will be used. Authority is constructed in that various communities may recognize different types of authority. It is contextual in that the information need may help to determine the level of authority required.**

Experts understand that authority is a type of influence recognized or exerted within a community. Experts view authority with an attitude of informed skepticism and an openness to new perspectives, additional voices, and changes in schools of thought. Experts understand the need to determine the validity of the information created by different authorities and to acknowledge biases that privilege some sources of authority over others, especially in terms of others' worldviews, gender, sexual orientation, and cultural orientations. An understanding of this concept enables novice learners to critically examine all evidence—be it a short blog post or a peer-reviewed conference proceeding—and to ask relevant questions about origins, context, and suitability for the current information need. Thus, novice learners come to respect the expertise that authority represents while remaining skeptical of the systems that have elevated that authority and the information created by it. Experts know how to seek authoritative voices but also recognize that unlikely voices can be authoritative, depending on need. Novice learners may need to rely on basic indicators of authority, such as type of publication or author credentials, where experts recognize schools of thought or discipline-specific paradigms.

### Knowledge Practices

Learners who are developing their information literate abilities

- define different types of authority, such as subject expertise (e.g., scholarship), societal position (e.g., public office or title), or special experience (e.g., participating in a historic event);
- use research tools and indicators of authority to determine the credibility of sources, understanding the elements that might temper this credibility;
- understand that many disciplines have acknowledged authorities in the sense of well-known scholars and publications that are widely considered "standard," and yet, even in those situations, some scholars would challenge the authority of those sources;
- recognize that authoritative content may be packaged formally or informally and may include sources of all media types;
- acknowledge they are developing their own authoritative voices in a particular area and recognize the responsibilities this entails, including seeking accuracy and reliability, respecting intellectual property, and participating in communities of practice;
- understand the increasingly social nature of the information ecosystem where authorities actively connect with one another and sources develop over time.

### Dispositions

Learners who are developing their information literate abilities

- develop and maintain an open mind when encountering varied and sometimes conflicting perspectives;
- motivate themselves to find authoritative sources, recognizing that authority may be conferred or manifested in unexpected ways;
- develop awareness of the importance of assessing content with a skeptical stance and with a self-awareness of their own biases and worldview;
- question traditional notions of granting authority and recognize the value of diverse ideas and worldviews;
- are conscious that maintaining these attitudes and actions requires frequent self-evaluation.

**Information Creation as a Process**

**Information in any format is produced to convey a message and is shared via a selected delivery method. The iterative processes of researching, creating, revising, and disseminating information vary, and the resulting product reflects these differences.**

The information creation process could result in a range of information formats and modes of delivery, so experts look beyond format when selecting resources to use. The unique capabilities and constraints of each creation process as well as the specific information need determine how the product is used. Experts recognize that information creations are valued differently in different contexts, such as academia or the workplace. Elements that affect or reflect on the creation, such as a pre- or post-publication editing or reviewing process, may be indicators of quality. The dynamic nature of information creation and dissemination requires ongoing attention to understand evolving creation processes. Recognizing the nature of information creation, experts look to the underlying processes of creation as well as the final product to critically evaluate the usefulness of the information. Novice learners begin to recognize the significance of the creation process, leading them to increasingly sophisticated choices when matching information products with their information needs.

**Knowledge Practices**

Learners who are developing their information literate abilities

- articulate the capabilities and constraints of information developed through various creation processes;
- assess the fit between an information product's creation process and a particular information need;
- articulate the traditional and emerging processes of information creation and dissemination in a particular discipline;
- recognize that information may be perceived differently based on the format in which it is packaged;
- recognize the implications of information formats that contain static or dynamic information;
- monitor the value that is placed upon different types of information products in varying contexts;
- transfer knowledge of capabilities and constraints to new types of information products;
- develop, in their own creation processes, an understanding that their choices impact the purposes for which the information product will be used and the message it conveys.

**Dispositions**

Learners who are developing their information literate abilities

- are inclined to seek out characteristics of information products that indicate the underlying creation process;
- value the process of matching an information need with an appropriate product;
- accept that the creation of information may begin initially through communicating in a range of formats or modes;
- accept the ambiguity surrounding the potential value of information creation expressed in emerging formats or modes;
- resist the tendency to equate format with the underlying creation process;
- understand that different methods of information dissemination with different purposes are available for their use.

**Information Has Value**

**Information possesses several dimensions of value, including as a commodity, as a means of education, as a means to influence, and as a means of negotiating and understanding the world. Legal and socioeconomic interests influence information production and dissemination.**

The value of information is manifested in various contexts, including publishing practices, access to information, the commodification of personal information, and intellectual property laws. The novice learner may struggle to understand the diverse values of information in an environment where "free" information and related services are plentiful and the concept of intellectual property is first encountered through rules of citation or warnings about plagiarism and copyright law. As creators and users of information, experts understand their rights and responsibilities when participating in a community of scholarship. Experts understand that value may be wielded by powerful interests in ways that marginalize certain voices. However, value may also be leveraged by individuals and organizations to effect change and for civic, economic, social, or personal gains. Experts also understand that the individual is responsible for making deliberate and informed choices about when to comply with and when to contest current legal and socioeconomic practices concerning the value of information.

## Knowledge Practices

Learners who are developing their information literate abilities

- give credit to the original ideas of others through proper attribution and citation;
- understand that intellectual property is a legal and social construct that varies by culture;
- articulate the purpose and distinguishing characteristics of copyright, fair use, open access, and the public domain;
- understand how and why some individuals or groups of individuals may be underrepresented or systematically marginalized within the systems that produce and disseminate information;
- recognize issues of access or lack of access to information sources;
- decide where and how their information is published;
- understand how the commodification of their personal information and online interactions affects the information they receive and the information they produce or disseminate online;
- make informed choices regarding their online actions in full awareness of issues related to privacy and the commodification of personal information.

## Dispositions

Learners who are developing their information literate abilities

- respect the original ideas of others;
- value the skills, time, and effort needed to produce knowledge;
- see themselves as contributors to the information marketplace rather than only consumers of it;
- are inclined to examine their own information privilege.

## Research as Inquiry

**Research is iterative and depends upon asking increasingly complex or new questions whose answers in turn develop additional questions or lines of inquiry in any field.**

Experts see inquiry as a process that focuses on problems or questions in a discipline or between disciplines that are open or unresolved. Experts recognize the collaborative effort within a discipline to extend the knowledge in that field. Many times, this process includes points of disagreement where debate and dialogue work to deepen the conversations around knowledge. This process of inquiry extends beyond the academic world to the community at large, and the process of inquiry may focus upon personal, professional, or societal needs. The spectrum of inquiry ranges from asking simple questions that depend upon basic recapitulation of knowledge to increasingly sophisticated abilities to refine research questions, use more advanced research methods, and explore more diverse disciplinary perspectives. Novice learners acquire strategic perspectives on inquiry and a greater repertoire of investigative methods.

### Knowledge Practices

Learners who are developing their information literate abilities

- formulate questions for research based on information gaps or on reexamination of existing, possibly conflicting, information;
- determine an appropriate scope of investigation;
- deal with complex research by breaking complex questions into simple ones, limiting the scope of investigations;
- use various research methods, based on need, circumstance, and type of inquiry;
- monitor gathered information and assess for gaps or weaknesses;
- organize information in meaningful ways;
- synthesize ideas gathered from multiple sources;
- draw reasonable conclusions based on the analysis and interpretation of information.

### Dispositions

Learners who are developing their information literate abilities

- consider research as open-ended exploration and engagement with information;
- appreciate that a question may appear to be simple but still disruptive and important to research;
- value intellectual curiosity in developing questions and learning new investigative methods;
- maintain an open mind and a critical stance;
- value persistence, adaptability, and flexibility and recognize that ambiguity can benefit the research process;
- seek multiple perspectives during information gathering and assessment;
- seek appropriate help when needed;
- follow ethical and legal guidelines in gathering and using information;
- demonstrate intellectual humility (i.e., recognize their own intellectual or experiential limitations).

**Scholarship as Conversation**

**Communities of scholars, researchers, or professionals engage in sustained discourse with new insights and discoveries occurring over time as a result of varied perspectives and interpretations.**

Research in scholarly and professional fields is a discursive practice in which ideas are formulated, debated, and weighed against one another over extended periods of time. Instead of seeking discrete answers to complex problems, experts understand that a given issue may be characterized by several competing perspectives as part of an ongoing conversation in which information users and creators come together and negotiate meaning. Experts understand that, while some topics have established answers through this process, a query may not have a single uncontested answer. Experts are therefore inclined to seek out many perspectives, not merely the ones with which they are familiar. These perspectives might be in their own discipline or profession or may be in other fields. While novice learners and experts at all levels can take part in the conversation, established power and authority structures may influence their ability to participate and can privilege certain voices and information. Developing familiarity with the sources of evidence, methods, and modes of discourse in the field assists novice learners to enter the conversation. New forms of scholarly and research conversations provide more avenues in which a wide variety of individuals may have a voice in the conversation. Providing attribution to relevant previous research is also an obligation of participation in the conversation. It enables the conversation to move forward and strengthens one's voice in the conversation.

**Knowledge Practices**

Learners who are developing their information literate abilities

- cite the contributing work of others in their own information production;
- contribute to scholarly conversation at an appropriate level, such as local online community, guided discussion, undergraduate research journal, conference presentation/poster session;
- identify barriers to entering scholarly conversation via various venues;
- critically evaluate contributions made by others in participatory information environments;
- identify the contribution that particular articles, books, and other scholarly pieces make to disciplinary knowledge;
- summarize the changes in scholarly perspective over time on a particular topic within a specific discipline;
- recognize that a given scholarly work may not represent the only – or even the majority – perspective on the issue.

**Dispositions**

Learners who are developing their information literate abilities

- recognize they are often entering into an ongoing scholarly conversation and not a finished conversation;
- seek out conversations taking place in their research area;
- see themselves as contributors to scholarship rather than only consumers of it;
- recognize that scholarly conversations take place in various venues;
- suspend judgment on the value of a particular piece of scholarship until the larger context for the scholarly conversation is better understood;
- understand the responsibility that comes with entering the conversation through participatory channels;
- value user-generated content and evaluate contributions made by others;
- recognize that systems privilege authorities and that not having a fluency in the language and process of a discipline disempowers their ability to participate and engage.

## Searching as Strategic Exploration

**Searching for information is often nonlinear and iterative, requiring the evaluation of a range of information sources and the mental flexibility to pursue alternate avenues as new understanding develops.**

The act of searching often begins with a question that directs the act of finding needed information. Encompassing inquiry, discovery, and serendipity, searching identifies both possible relevant sources as well as the means to access those sources. Experts realize that information searching is a contextualized, complex experience that affects, and is affected by, the cognitive, affective, and social dimensions of the searcher. Novice learners may search a limited set of resources, while experts may search more broadly and deeply to determine the most appropriate information within the project scope. Likewise, novice learners tend to use few search strategies, while experts select from various search strategies, depending on the sources, scope, and context of the information need.

### Knowledge Practices

Learners who are developing their information literate abilities

- determine the initial scope of the task required to meet their information needs;
- identify interested parties, such as scholars, organizations, governments, and industries, who might produce information about a topic and then determine how to access that information;
- utilize divergent (e.g., brainstorming) and convergent (e.g., selecting the best source) thinking when searching;
- match information needs and search strategies to appropriate search tools;
- design and refine needs and search strategies as necessary, based on search results;
- understand how information systems (i.e., collections of recorded information) are organized in order to access relevant information;
- use different types of searching language (e.g., controlled vocabulary, keywords, natural language) appropriately;
- manage searching processes and results effectively.

### Dispositions

Learners who are developing their information literate abilities

- exhibit mental flexibility and creativity;
- understand that first attempts at searching do not always produce adequate results;
- realize that information sources vary greatly in content and format and have varying relevance and value, depending on the needs and nature of the search;
- seek guidance from experts, such as librarians, researchers, and professionals;
- recognize the value of browsing and other serendipitous methods of information gathering;
- persist in the face of search challenges, and know when they have enough information to complete the information task.

Appendix B

Qualtrics Survey: Task Instructions, Demographic Questions,

Elaborative Prompts (Treatment Conditions Only), and Texts

**Learning about Climate Change from Multiple Sources**

**Purpose of the Study:** You are being invited to participate in a research study and your participation is voluntary. This consent statement will provide you with information about the research project.  This research project investigates how people gather ideas from multiple sources of information on a topic such as climate change. This research may not directly benefit you, however, your responses will provide a valuable contribution to our understanding of how people gather ideas from multiple documents. The potential benefits you may experience in this study may include learning about the topic of climate change.  Procedure Before the experiment, you will be asked a few basic demographic questions. After responding to these, you will be given the topic description followed by a few initial questions, and then presented with texts on the topic of climate change. You will type in your responses in the space provided below each question. The study requires approximately 60-minutes to complete. Privacy and Confidentiality Your study related information will be kept confidential. Any identifying information collected will be kept in a secure location and only the researchers will have access to the data. Research participants will not be identified in any publication or presentation of research results. Your identity as a participant will remain confidential. We expect the findings of this study will be published in a scientific journal; no information that identifies you by name will be released. Compensation You will receive $1.00 for participation. You may participate only once in this study. Consent Statement I have read this consent statement and understand the information that has been provided above. I voluntarily agree to participate in this study. I certify that I am at least 18 years of age and that I understand that a copy of this consent form will be emailed to me for future reference upon request.

○ Agree  (1)

○ Don't Agree  (2)

**Demographic Questions**

Q1 Age: What is your age?

○ 18-24 years old  (1)

○ 25-34 years old  (2)

○ 35-44 years old  (3)

○ 45 years or older  (4)

Q2 Gender: To which gender identity do you most identify?

○ Female  (1)

○ Male  (2)

○ Other  (3) _____

○ Prefer not to answer  (4)

Q3 Education: What is the highest degree or level of school you have completed?

○ Some high school, no diploma  (1)

○ High school graduate, diploma or the equivalent (for example: GED)  (2)

○ Some college credit, no degree  (3)

○ Associate degree  (4)

○ Bachelor's degree  (5)

○ Master's/doctorate degree  (6)

**Task Instructions:** Imagine that you have to write a brief report to other students in your class where you express and justify your personal opinion about climate change. Your task is to write a short paragraph (no more than 500 words) that states your position on climate change. Base your report on information included in the five information sources on the following pages. At the end of each source, you will be asked a few questions. You may write short responses in the form of bullet points to answer these questions. You may go back to any information source to reread the text if you wish to do so. Use the most relevant information and try to express yourself clearly preferably in your own words. After you have read all the texts, write your report using the space provided on the last page. Base your report on the information included in the five provided texts.

Before you begin reading the information sources, answer the following questions.

Q4 What do you already know about the topic?

_____

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_____

Q5 What questions come to your mind after you have read the topic description?

_____

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_____

Q6 On a scale of 1-10, (1 representing least interest, and 10 representing most interest), how interested are you in the topic of climate change?

Interest in climate change (1)          1                              10

**Text 1**: The earth's climate has always changed over time. Such climate changes have until recently had natural causes such as changes in the strength of the sun, changes in the earth's orbit around the sun, and volcanic eruptions. It now appears that for the first time mankind is facing a global climate change caused by its own activities.

**The natural greenhouse effect**: The greenhouse effect is primarily a natural and necessary process. The sun has a surface temperature of approx. 6,000 °C and emits various kinds of radiation. Half of the sunrays that hit the earth's atmosphere penetrate down to the surface of the earth, the rest are reflected by clouds and other gases. Most of the sunrays that reach the earth have short wavelengths. They warm the surface of the earth, which sends back long wavelength streams of heat. A large proportion of these streams returned from the earth are absorbed by the clouds and the gases in the atmosphere, which then send the radiated heat back to us. Some of these gases in the atmosphere are called climate gases. The most important climate gases are water vapour, carbon dioxide and methane. They form a heat shield that slows down the radiation of heat from the earth. This results in the surface of the earth and the air layer being heated up. This is the same that takes place in a greenhouse where sunlight penetrates the glass panes, but radiated heat is restrained on its way out. The result is that the greenhouse is warmer than its surroundings. Without this natural greenhouse effect the average temperature on earth would be -18 °C instead of the 15 °C it is today.

**The manmade greenhouse effect**: In recent times, climate researchers have found that the earth's average temperature rose by approx. 0.5 °C between 1850 and 2004. From around 1900 until the present day the level of carbon dioxide in the air has increased from less than 0.03% to almost 0.04%, and it appears that this increase is continuing. This is due to the fact that we have increased our discharges of CO2 into the atmosphere through the burning of large quantities of oil, gas and coal. Human activities have also resulted in increased discharges of other climate gases. This can result in more of the heat being stopped from escaping from the earth and the average temperature rising even more.

Q7 As you examine this source, what new themes emerge about the topic?

_____

_____

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**Text 2:** The UN's climate panel concludes in its third main report from 2001 that it is highly probable that manmade discharges of climate gases have contributed significantly to the climate changes observed in the last 30 to 50 years.

**Manmade greenhouse effect:** Since pre-industrial times (around 1750) the concentration of carbon dioxide ($CO_2$) has increased by around 31 per cent, the concentration of methane ($CH_4$) has increased by around 151 per cent and the concentration of nitrogen oxide ($N_2O$) has increased by around 17 per cent. These increases are due to manmade discharges and have resulted in a *stronger* greenhouse effect. Human activities have also introduced into the atmosphere smaller quantities of a number of climate gases that do not exist in the atmosphere naturally. The increase in the concentration of $CO_2$ in the atmosphere forms the primary constituent (around 60%) of the strengthening of the greenhouse effect for which mankind is responsible. These manmade discharges of $CO_2$ are first and foremost due to the consumption of fossil fuels (coal, oil and gas) and the deforestation of tropical regions. Mankind's discharges amount to only a small part of the quantity of climate gases released into the atmosphere and the effect is minor in relation to, for example, the effect of naturally occurring water vapour. The problem is that the climate system is very complex and sensitive, and even small changes in the system can trigger major consequences. Nature's own discharges of climate gases form part of a cycle in which, for example, rotting trees release $CO_2$ and living trees absorb $CO_2$ through photosynthesis. Our $CO_2$ discharges from, among other things, the burning of fossil fuels do not form part of this cycle and result in surplus $CO_2$ which remains in the atmosphere for a long time.

Q8 As you examine this source, what new themes emerge about the topic? How are these themes related to what you read in other source(s)?

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**Text 3:** Climate has always varied over time and will continue to do so. This is a normal state of affairs. Changes to the earth's climate are to a large extent steered by astronomical conditions. For example, small changes in the earth's orbit around the sun and changes in the tilt with respect to the earth's rotational axis – which is responsible for us having seasons – are associated with significant climate changes. Changeovers between ice ages and warmer periods are demonstrably linked to these external astronomical conditions.

**The sun affects the layer of clouds:** Without the sun we would not have the greenhouse effect, which is a prerequisite for us having liveable conditions on our planet. Even small variations in the radiation from the sun will affect the climate. The sun is a magnetic star and areas of its surface have strong magnetic fields. These affect its radiation and can result in both weak increases and decreases, and these in turn affect the climate even in the case of changes at the per thousand level. The sun's magnetic fields surround both the earth and the other planets. When particles that originate from previously exploded stars penetrate the atmosphere, they could affect the formation of low clouds. This in turn has an effect on the earth's weather. The sun's magnetic field will, to a varying degree, stem the quantity of particles that penetrate our atmosphere. This could function as an "on/off" switch for the layer of clouds around the earth. There has been much debate about climate in recent years and the discussion has often been about the extent to which mankind's activities are affecting our climate in relation to the natural variations. We still do not have a basis for establishing that human pollution of the atmosphere is the main cause of climate change.

Q9 As you examine this source, what new themes emerge about the topic? How are these themes related to what you read in other source(s)?

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**Text 4:** Stronger storms, more hurricanes and increasingly tumultuous weather are just a few of the negative consequences we can expect in the next few years. Global warming may also weaken the Gulf Stream and result in serious cooling in Northern Europe.

A number of oceanographers fear highly uncomfortable side effects due to global warming. It may weaken the ocean currents in the North Atlantic to such a degree that there is a genuine risk of serious and long-term cooling both in the Nordic Region and large parts of Europe and North America. The Nordic Region would be significantly colder without the Gulf Stream.

Oceanographers know all too well that the warnings will cause surprise because we are reminded almost daily of the opposite, namely that global warming will raise the earth's average temperature. However, paradoxically, both things could well occur at the same time. If the circulation of the Atlantic is disturbed, we could have a fall in the average temperature of 3-5 °C. This will have a dramatic effect on farming and forestry, while at the same time there will be a greater need for heating.

And there is much that indicates that the disturbances are well underway. More ice is melting due to global warming and more precipitation is falling over, among other places, Russia. This is resulting in greater outward flows of freshwater from the major Russian rivers into the Arctic Ocean. At the same time we risk losing the Western Arctic ice and Greenland ice.

When the ice surrounding the poles melts, this will not just result in an increased mass of water, it will also result in increased evaporation from the oceans. This will provide hurricanes with energy. Time magazine reports that hurricanes have increased in both number and intensity since 1995.

According to the UN's climate panel, an increased greenhouse effect resulted in water levels rising between 10 and 20 cm in the last century and by 2100 ocean levels will rise by between 9 and 88 cm. This will be catastrophic for many coastal communities – especially in developing countries.

Q10 As you examine this source, what new themes emerge about the topic? How are these themes related to what you read in other source(s)?

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**Text 5:** Temperatures around the North Pole are increasing at double the rate of other places around the globe according to UN experts. The Arctic ice is melting so quickly that a sea passage between the Atlantic Ocean and the Pacific Ocean may be accessible to ordinary ships during the summer by 2050. The route through the Northwest Passage to Asia will reduce the journey distance between London and Tokyo from 21,000 to 16,000 kilometres.

The northerly regions that are becoming accessible also conceal enormous riches. The oil and gas deposits that are concealed there are estimated to amount to 30 per cent of the earth's deposits. And there is more to be found in the northerly regions than petroleum. There is also gold, diamonds, copper and zinc. There will be a lot of traffic due to such exploration says Frederic Lasserre, a geographer at Laval University in Quebec in Canada who is a specialist in Arctic regions. The director of the Nansen Environmental and Remote Sensing Center, also points out positive consequences of global warming, which occurs in the Arctic in particular: - A warmer climate could result in better growing conditions and lower heating costs. The ice in the Barents Sea will be pushed northwards and eastwards due to increasing south-westerly winds and warmer weather. This will expand winter fishing grounds and make it easier for the gas and oil industry to operate during the winter season.

Q11 As you examine this source, what new themes emerge about the topic? How are these themes related to what you read in other source(s)?

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Q12 Now that you have read all the provided texts related to the topic of climate change, write your report using the space provided below. Base your report on the information included in the five provided texts.

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_____

_____

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