EFFECTS OF BACKGROUND CONTEXT AND SIGNALING ON COMPREHENSION RECALL AND COGNITIVE LOAD: THE PERSPECTIVE OF COGNITIVE LOAD THEORY

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EFFECTS OF BACKGROUND CONTEXT AND SIGNALING
ON COMPREHENSION RECALL AND COGNITIVE LOAD:
THE PERSPECTIVE OF COGNITIVE LOAD THEORY

By

Minjung Song

A DISSERTATION

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EFFECTS OF BACKGROUND CONTEXT AND SIGNALING ON COMPREHENSION RECALL AND COGNITIVE LOAD: THE PERSPECTIVE OF COGNITIVE LOAD THEORY

Minjung Song, Ph.D.

University of Nebraska, 2011

Advisor: Roger Bruning

This study was designed to examine the effects of different geographical background contexts for information on comprehension, recall, and cognitive load. Two different contexts, American geographical background and Korean geographical background, were employed to frame explanations of global warming phenomena. Students’ comprehension was calibrated by two different levels of measurement, which were fact-level learning (shallow understanding) and inference-making (deep understanding). Cognitive load was gauged by self-reported levels of motivation, difficulty, and mental effort. It was hypothesized that an American context would be more familiar and Korean context less familiar for American students. It was also hypothesized that unfamiliar contexts would create disadvantages in comprehension, recall, and cognitive load, but that signaling would improve comprehension and recall and reduce cognitive load, especially in unfamiliar contexts.

Students from two educational psychology courses were randomly assigned to one of four groups in which they read one of the four different types of passages online: an American signaled passage, an American nonsignaled passage, a Korean signaled passage, and a Korean nonsignaled passage. Participants took comprehension and recall tests and reported their perceived levels of motivation, difficulty, and mental effort in the
same online environment. Results were analyzed by MANCOVA (multivariate analysis of covariance). The analyses revealed that (1) students were significantly more confident in their American geographical prior knowledge, which was interpreted as an indicator that an American context for information was more familiar to them; (2) context familiarity had positive effects on students’ levels of inference-making, their self-reported levels of motivation, and perceived levels of difficulty; and (3) signaling had a negative effect on inference-making. An expertise reversal effect was noted for participants’ deep understanding. The findings of the current study imply that learning materials that are framed within an unfamiliar context can create disadvantages for students’ motivation and deep comprehension. Future research is needed to find ways for compensating for those disadvantages.
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Chapter I

Introduction

A body of research from the perspective of schema theory has shown how readers’ perspectives and prior knowledge are important in comprehending and remembering what they read. Anderson and his colleagues (Anderson, 1978; Anderson & Pearson, 1984; Anderson, Reynolds, Schallert, & Goetz, 1977), Bransford and Johnson (1972), and Rumelhart (1981), for example, have shown that readers’ prior knowledge and the perspectives suggested for readers, as well as titles provided for ambiguous passages can have significant effects not only on the amount of information readers remember but also on what they comprehend.

Applied to reading, the basic premise of schema theory is that readers’ prior knowledge and their schemata will have significant effects on what they comprehend when they read and on what they will later remember. In other words, how well readers comprehend and remember what they read is contingent on how well readers’ prior knowledge is induced. The cultural schemata readers possess are one of the many factors that help evoke their prior knowledge. Culturally familiar text more easily activates readers’ prior knowledge and thus it is more easily comprehended and remembered. Pritchard (1990), Reynolds, Taylor, Steffensen, Shirey, and Anderson (1982) and Steffensen, Joag-Dev, and Anderson (1979), for instance, have shown the importance of cultural schemata in comprehending and remembering discourse. Likewise, familiar context activates readers’ prior knowledge. Information appearing in more familiar contexts is better recalled because the familiar context makes it easier to arouse a reader’s
schemata and in turn, the schemata play an important role in remembering and comprehending the text contents (Freebody & Anderson, 1983).

Context has been defined in a variety of ways across studies. For example, researchers have considered words, sentences, paragraphs, a whole story, settings, and culture as context. Overall, context has been shown to have a significant effect on outcomes ranging from word recognition (e.g., Stanovich & West, 1981) and vocabulary learning (e.g., Beck, Mckeown, & McCaslin, 1983) to reading comprehension (e.g., Carey, Harste, & Smith, 1981).

The present study examined the role of context in comprehension and recall. Context in this study was defined by two different geographical backgrounds used in text materials describing the global warming phenomenon. It was assumed that for American college students, information situated in a geographically familiar context (i.e., in the context of a U. S. geographical illustration) would be better comprehended and better recalled than information presented in geographically less familiar context (in the context of Korean geographical illustration). This assumption can easily be made and nothing is new here.

In the present study, however, two different kinds of text (geographically familiar text vs. unfamiliar text) were investigated with the perspective of cognitive load theory. According to cognitive load theory, individuals have limited working memory and their learning cannot be efficient if the processes of learning exceed the capacity of working memory for any reason (Chandler & Sweller, 1996; Sweller, 1988). Based on that assumption, in the current study, it was hypothesized that a geographically unfamiliar context (Korean context) would generate more cognitive load for American students than
a familiar (American) context and those readers who encounter information situated in an unfamiliar context would be disadvantaged.

In some educational situations, such as teaching geography and history, encounters with unfamiliar cultural and foreign geographical context are unavoidable and even desirable. In those instances, ways need to be found to boost readers’ understanding and remembering. In the present study, signaling was suggested as a way of reducing cognitive load caused by unfamiliar context and optimizing readers’ comprehension and recall. Signaling is typically designed to guide readers to important content or structure and makes the content and the relationships clearer without changing the content itself (Loman & Meyer, 1983; Meyer, 1975). Thus, in the present study, it was also hypothesized that signaling could reduce cognitive load as well as improve comprehension and recall, especially in unfamiliar contexts. The sections following provide a brief summary of each of the major theoretical perspectives important to the current study, beginning with schema theory.

Roles of Schemata in Comprehension

A schema (plural schemata) is defined as a knowledge framework that represents a class of things, events and situations (Anderson, 1978). A reader’s understanding is facilitated when a schema provides an interpretive framework that helps individuals interpret data, retrieve information from memory, and determine goals and subgoals (Anderson & Pearson, 1984; Rumelhart, 1981). According to schema theorists, to comprehend stories and texts, readers should bring schemata that provide good explanations about the objects and events in the passages. Rumelhart (1981), for example, addressed the importance of schemata by identifying three reasons that readers might not
correctly understand a passage. If readers do not have proper schemata, and if the clues in the passage are not enough to activate the readers’ schemata even though they have proper ones, a text cannot be fully understood. At the same time, however, if readers bring schemata to their reading that are not the ones the author intended, they will have a problem understanding the passage.

It is also generally accepted that schemata facilitate encoding and retrieval. If readers employ appropriate schemata at the time of reading, the reading materials will be more effectively encoded by helping information get encoded more precisely and by enabling readers to be attentive to more important text elements. Similarly, a schema can help individuals retrieve information more successfully by facilitating a search of memory, providing the standard for editing out unimportant information and allowing inferential reconstruction (Anderson, Pichert, & Shirey 1983). Thus, information will be retrieved more easily through the assistance of schemata.

Schemata smooth the progress of understanding as well. The way readers comprehend a passage depends on what they know. Readers who have appropriate schemata about the reading material can easily make connections between what they are reading and what they know. In other words, if reading materials effectively evoke readers’ schemata or their prior knowledge, they will be easily understood and remembered, but if they don’t, readers will face difficulties. Therefore, schema theorists argue that a reader’s schema provides an interpretative framework for comprehending discourse, and that schema theory provides a good explanation of how familiar situations are comprehended more easily (Anderson, Wang, & Gaffney, 2006; Freebody & Anderson, 1983).
One often-used example that evokes familiar situations and offers a variety of relevant schemata is culture. Several studies showed the importance of cultural schemata in comprehending written materials (Pritchard, 1990; Reynolds, Taylor, Steffensen, Shirey, & Anderson, 1982; Steffensen, Joag-Dev, Anderson, 1979). Culturally familiar text was more easily understood and remembered because the text easily evokes readers’ background knowledge and relevant schemata. If readers do not have appropriate cultural schemata, however, they can misunderstand the text. The study by Steffensen, Joag-Dev, and Anderson (1979) showed the importance of cultural schemata in reading comprehension. In their study, American students and Indian students read two letters about a wedding: one was about an American wedding and the other about an Indian wedding. Results showed that students remembered and elaborated more information from their respective native passages whereas they distorted more information from the foreign passage.

In summary, according to schema theorists, schemata are indispensable for discourse comprehension because understanding discourse depends on the processes of activating or constructing schemata that gives a good account for objects and events in a text (Anderson, 1984).

Context Effects on Learning

The term context has been defined differently in many studies according to their purposes, but the term can be described most directly with respect to text materials in two ways. Context narrowly includes a word, a sentence, or a passage in a text that make the meaning of a certain part of discourse clear, but context also broadly comprises a set of facts or circumstances that are implied within a certain segment of discourse.
Accordingly, discourse cannot be understood without acquiring contextualized knowledge about it (Bruning, Schraw, & Norby, 2011).

A body of research has been conducted to examine the effect of context on word identification, word recognition, lexical decision, new vocabulary acquisition and reading comprehension. In order to examine the context effect on word recognition and lexical decision, a narrow meaning of context was used such as a single word (e.g., Meyer & Schvaneveldt, 1971) and a sentence frame (e.g., Kleiman, 1980). On the other hand, a more broad meaning of context was employed when the effect of context on new vocabulary learning and reading comprehension. Usually, in the field of new vocabulary learning, context refers to the content in which an unknown word is inserted (e.g., Nagy, Anderson, & Herman, 1987), but context in reading comprehension also is provided by background knowledge (Bransford & Johnson, 1972), settings (Carey, Harste, & Smith, 1981) and culture (Steffensen, Joag-dev, & Anderson, 1979) in reading comprehension.

Early studies verified that even the context provided by a single word could facilitate word identification, with significantly shorter times when two words were associated (e.g., James, 1975; Schvaneveldt & Meyer, 1973). Similarly, the reaction time is shorter in lexical decision when an appropriate sentence frame context was offered (Kleiman, 1980). However, Kintsch and Mross (1985) demonstrated that the associative context (the association strength between two words) and thematic context (the meaning of the discourse) influenced word identification and lexical decisions differently depending on the amount of time allowed. Lexical decisions were contingent on the thematic context when enough time is provided (sense selection) while the associative
context was more heavily relied on when the decision needed to be made quickly (sense activation).

Regarding new vocabulary learning, most scholars agree that people learn the majority of new vocabulary incidentally from context with only a small amount of vocabulary growth ascribed to vocabulary instruction. However, it was not easy to obtain a significant effect of context on vocabulary learning in experimental settings due to the limited exposure to a passage and new vocabularies in restricted time. People usually gain only a little of their knowledge of a word when they encounter the word the first time, so learning vocabulary from context typically takes place in small increments (Nagy, Anderson, & Herman, 1987). However, this small increase can result in large vocabulary growth with a sufficient volume of reading (Nagy, Herman, and Anderson, 1985).

Reading comprehension cannot be achieved unless readers add contextual information to the reading materials (Bransford & Johnson, 1972). Contextual information could be extracted from readers’ prior knowledge, settings, culture and needless to say, it is acquired from reading material itself. Prior knowledge is an essential element that helps readers construct meaning from text. Also, settings in which reading occurs help readers draw the necessary relations between concepts in the text and the environments. Similarly, a cultural background of the reading material evokes readers’ cultural knowledge. Therefore, appropriate background knowledge (McKewon, Beck, Sinatra, & Loxterman, 1992), settings (Carey, Harste, & Smith, 1981), and cultural background (Steffensen, Joag-dev, & Anderson, 1979) can serve as context and improve reading comprehension. In brief, context generally facilitates word recognition, lexical
decision, learning new vocabulary and reading comprehension, irrespective of whether a context is a word, a sentence, settings, and culture.

Signaling Effects on Learning

A number of studies have examined the effect of signaling on attention, recall, and reading comprehension. In those studies, the term of signaling was used to refer to the addition of noncontent words that emphasize certain aspects of the semantic content, structure or organization of the passage (Loman & Meyer, 1983). In general, signaling guides readers to focus on a certain aspect of content or structure without adding or changing the content and as a result, the readers can understand the content and the relationships in text more clearly (Meyer, 1975).

One function of signaling is facilitating the selection process in text by assisting readers in making decisions about which information is significant. As a result, readers’ attention is more invested in the signaled elements and the recall of them is enhanced as well. The function of signaling on attention and recall has been confirmed by several studies (e.g., Loman & Mayer, 1983; Lorch & Lorch, 1996; Lorch, Lorch, & Inman, 1993). The participants who read signaled version of text recalled significantly more signaled points than those who read nonsignaled version, presumably because signals direct readers to focus more on important information (Mautone & Mayer, 2001) and thus recall of that part was facilitated. However, several studies have failed to demonstrate positive signaling effects on overall text recall (e.g., Brooks, Dansereau, Spurlin, & Holley, 1983; Lorch, Lorch, & Inman, 1993). The recall of signaled information was increased whereas the recall of unsignaled information was decreased in the third experiment of Lorch and Lorch (1996)’s study. They argue that organizational signals
such as overviews, summaries and headings did not increase overall recall because the unsignaled part received less attention and the recall for that part was reduced.

Another function of signaling is smoothing the process of organizing information by making the relations in text clear (Lorch, 1989). Headings, list signals (e.g., *first, second and finally*), overviews, summaries and previews assist readers in forming coherent representation through serving as organizing devices. Because signaling enhances constructing coherent representation, readers’ comprehension benefits from it. Studies that examined the effect of signals on readers’ comprehension employed problem solving task (Loman & Mayer, 1983) and making inference problems (Spyridakis & Standal, 1987). Participants who read the text with signals performed better on those tasks.

The other function of signaling is reducing cognitive load (Mautone & Mayer, 2001). In other words, signaling helps readers invest fewer cognitive resources in selecting essential information and in integrating and organizing information in text. As a result, more cognitive capacity is left for constructing deeper representation and understanding the content. Readers’ understanding and grasping important points about what they read thus are enhanced and improved.

**Optimization of Cognitive Load**

Cognitive load theory (CLT) has been established on the assumption that human cognition has limited working memory and the idea that if learning materials exceed the capacity of working memory for any reason, learning outcomes will not be optimal. CLT has been used in devising methods for decreasing working memory load when individuals learn new materials (van Merriënboer & Sweller, 1991). A body of
research has attempted to find effective instructional methods that help learners fully invest available cognitive resources in learning (e.g., Chandler & Sweller, 1996; Paas & van Merriënboer, 1994a; Sweller, 1988). Accordingly, CLT has contributed to increasing the effectiveness of learning and decreasing unnecessary efforts that are not directly related to learning itself. A variety of instructional methods found based on cognitive load theory have shown learning outcomes to be enhanced when learning materials are well-integrated and learners’ attention is not diverted away from key concepts.

CLT has been explored in studies identifying drawbacks in conventional instruction, for example, means-ends processes in problem solving (Sweller, 1983; Sweller & Levine, 1982). Since the purpose of the means-ends analysis is primarily to attain the problem goal, it may not be particularly helpful for understanding relationships and learning the rules. Thus, this conventional instruction method may prevent schema construction, which is the crucial object of learning, through making the learners devote too many of their mental resources to attaining the goal. Sweller and Levine (1982) found that means-ends analysis imposed unnecessary effort that interfered with essential learning and that students learned more from goal-free problems than means-ends analysis.

Successive studies demonstrated that other alternative instructional methods, such as worked examples (Cooper & Sweller, 1987; Paas, 1992; Paas & van Merriënboer, 1994b; Sweller & Cooper, 1985) and completion problems (Paas, 1992; van Merriënboer, 1990) were more effective methods in teaching and learning than the conventional instruction using means-ends analysis because those alternative instructional methods were designed to reduce cognitive load. Moreover, several practical findings, such as the
modality effect (reducing cognitive load by adopting two different modes of presentation, e.g., Sweller, 1999), redundancy effect (decreasing cognitive load by eliminating redundant information, e.g., Chandler & Sweller, 1991), and expert reversal effect (providing additional information is redundant and has negative rather than positive effects for experts, e.g., Kalyuga, Ayres, Chandler & Sweller, 2003) have been discovered.

Research based on CLT suggests that learning is optimized by removing unnecessary load that is not relevant for schema construction. In other words, getting rid of unnecessary load facilitates schema construction and schema automation. Therefore, anything that gives unnecessary load should be eliminated whereas anything that helps schema construction and schema automation should be emphasized to enhance learning.

The Present Study

The present study was designed (1) to examine the effects of different geographical background contexts for information (a familiar American setting versus an unfamiliar Korean setting) on comprehension and recall of American students, (2) to explore the effects of signaling (e.g., titles, headings, previews, summary statements, logical connectives, and typographical cues) that was inserted to guide readers’ attention to certain aspects in the passage on comprehension and recall, and (3) to utilize CLT and measures of cognitive load to better understand effects that were observed. Students from two educational psychology courses at a large Midwestern research university participated in the current study. Students’ comprehension was gauged by 25 fact questions and 5 inference-making questions. Their recall was evaluated by a single question about how many university names they recalled from those that previously had
been highlighted (boldface) in the text materials. Cognitive load was assessed by students’ scores on subjective rating scales about their levels of motivation, difficulty, and mental effort.

In the primary manipulation of this study, the geographical context in which information about global warming appeared was varied (a familiar American context and an unfamiliar Korean context) and comprehension, recall and cognitive load were examined as a function of that variation. It was hypothesized that unfamiliar background context would lead to disadvantages in comprehension, recall, and cognitive load because unfamiliar context makes it hard to induce readers’ schemata and prior knowledge. The second dimension of the study, signaling, was hypothesized to overcome the disadvantages caused by unfamiliar context. Signaling describes a set of text-related approaches that are designed to help readers pay more attention to important aspects and relations in the text. As a result of signaling, it was expected that their comprehension and recall generally would be improved. It also was predicted, however, that because of cognitive load issues generated by an unfamiliar context for information, signaling devices would compensate for the difficulties caused by the unfamiliar context more effectively, even though signaling devices were expected to be useful in both familiar and unfamiliar context.

Because this study proposed to examine differences caused by context and signaling on comprehension, recall, and cognitive load and because it was likely that subjects’ prior knowledge about global warming would affect those dependent variables (comprehension, recall and cognitive load), MANCOVA (multivariate analysis of covariance) was employed. Students’ confidence in prior knowledge about global
warming and about American and Korean geography was measured and these scores were used as covariates. MANCOVA examined whether significant multivariate effects as well as univariate effects existed. If the results for multivariate tests are significant, it indicates the collection of dependent variables differs among the treatment conditions. If univariate tests are significant, it means the treatment conditions make a significant difference on the dependent variable being tested (Gardner, 2001).

This study was expected to add to previous research regarding reading comprehension and cognitive load theory by its examination of the effect of context on comprehension and recall from the perspective of cognitive load theory. The effects of sentence contexts as well as single-word context on word recognition and word identification have been explored by a number of studies (e.g., Kim & Goetz, 1994; Kleiman, 1980). Although a few studies employing a whole story context to examine the effect of cultural schemata on reading comprehension can be found (e.g., Reynolds, Taylor, Steffensen, Shirey, & Anderson, 1982; Steffensen, Joag-Dev, Anderson, 1979), little is known about the impact of readers’ familiarity with a geographical background context on their reading comprehension and recall of technical information. Because this writer’s review of research did not reveal any studies that have focused on the effect of geographical background context examined by the perspective of cognitive load theory, the current study adds new findings to previous research.

It also was judged to be valuable to investigate ways of improving students’ understanding of important information under circumstances that parallel those that students are likely to encounter in their science and history classes. In many classes, a significant proportion of the technical and historical information students encounter is
likely to be embedded in a unfamiliar background context. Such unfamiliar contexts may cause disadvantages in comprehension, recall, and cognitive load. By finding a way—signaling in the present study—to improve comprehension and recall and to reduce cognitive load, this study may contribute to understanding of how such problems can be addressed.
Chapter II

Review of Literature

The present study was designed to examine the effects of context and signaling on comprehension, recall, and cognitive load. It was expected that familiar and unfamiliar context would affect students’ comprehension, recall of information, and students’ self-reported levels of cognitive load created during reading differently due to the fact that familiar context would activate readers’ prior knowledge and schemata. Signaling was proposed in the present study to compensate for the disadvantaged circumstance caused by unfamiliar context. Therefore, analyzing and examining previous research focused on schema theory, context effects, signaling effects, and cognitive load theory were important steps in finding a way to discover valuable strategies for facilitating reading comprehension and recall in an unfamiliar and foreign context, and to help structure the present study. The literature review here provides theoretical perspectives for the design of the present experiment.

This review covers studies published in peer-reviewed journals that have schema theory, context effects, signaling effects, and cognitive load respectively as major interests. An overview of schema theory examines how readers’ schemata influence the way readers interpret reading materials and how readers’ schemata distort and facilitate their understanding and remembering. This overview then is tied to the current study, showing how familiar and unfamiliar context differently activate readers’ schemata and their prior knowledge.

Next, studies are reviewed that have investigated the different kinds of context effects, for example, context effects on word recognition, new vocabulary learning,
reading comprehension, and recall. These studies provide support for the hypothesis of the present study that the familiar and unfamiliar contextual information would differentially impact the ability of readers to draw the necessary relations to understand reading materials. The section following this reviews literature regarding various effects of signaling, which points to ways to mitigate learning difficulties caused by unfamiliar background contexts.

The fourth section, devoted to cognitive load theory, focuses on how various kinds of learning environments can cause overload of the cognitive system and how to reduce or optimize cognitive load. This research provides support for the idea in the current study that unfamiliar context would generate more cognitive load, especially more intrinsic load. This literature is used to justify employing signaling as an approach hypothesized to affect intrinsic load and reduce total cognitive load. Finally, the chapter concludes with a statement of hypotheses for the current study and a brief discussion of the study’s implications.

Schema Theory

A schema (plural schemata) is defined as a knowledge structure that represents a class of things, events and situations and that has components or subparts called slots (Anderson & Pearson, 1984). Individuals activate and employ these mental frameworks to interpret events. When schemata are activated, the slots are instantiated by specific information. Schema theory is a theory about how the knowledge is structured, and about how the knowledge structures facilitate the use of knowledge in particular ways.

According to schema theory, readers’ schemata provide the fundamental frameworks for understanding, learning, and remembering ideas in materials, and
facilitate those processes (Anderson, 1978; Anderson & Pearson, 1984; Rumelhart, 1981). In order to comprehend stories and texts, readers need to have appropriate schemata that provide good explanations about the objects and events in the passages. A body of research has shown that information is understood effectively when readers employ appropriate schemata. Text content that is tied to learners’ schemata also is more effectively remembered (Anderson, Reynolds, Schallert, & Goetz, 1977; Bransford & Johnson, 1972; Steffensen, Joag-Dev, & Anderson, 1979).

Several schema-based processes in learning and remembering have been identified. A schema helps the information to be encoded and learned more efficiently by allocating the learner’s attention to the important elements, providing ideational scaffolding for assimilating information, and enabling inferential elaboration when the text is not explicit (Anderson, 1994). Similarly, retrieval processes are facilitated by schemata guiding memory searches, providing standards for editing out unimportant information, and aiding inferential reconstruction when there are gaps in memory (Anderson, Pichert, & Shirey 1983). These processes will be reviewed in detail below.

Schemata enable information to be encoded more precisely because they provide slots for certain text information. As a consequence, the information consistent with the schema is easily remembered and learned with little mental effort. The schema provides what Anderson (1994) has called ideational scaffolding. Additionally, schemata enable readers to be guided to more important text elements and to allocate more attention to the text aspects consistent with their schemata. By doing so, important propositions in a text are connected with the overall representation that is being created. Making such
connections extends cognitive capacity and helps readers better recall the information that receives more attention (Anderson, 1978, 1994).

Schemata also facilitate making inferences. Readers make inferences at the time of reading as well as at the time of remembering. In order to fully understand a passage as the writer intends, readers need to make inferences for parts that are not explicitly addressed. A reader’s schema allows inferential elaboration at the time of encoding and inferential reconstruction at the time of retrieval. *Inferential elaboration* refers to the notion that a schema enables readers to make inferences about the information that is not explicitly stated in a text whereas *inferential reconstruction* refers to the process of a reader generating missing information depending on his/her schema when there are gaps in memory (Anderson, 1994). Just as scholars use theories to forecast unknown situations, readers use schemata to make inferences about unobserved or unremembered events (Rumelhart, 1981).

Furthermore, a schema provides a guide to the information that needs to be recalled. That is, a schema facilitates memory searches by providing the framework used to structure the text. The readers are aided by schemata to get access to the specific information encoded when they read the text. Also, schemata help readers edit out unimportant information and remember important information more effectively. Because a schema itself contains a standard of importance, it enables readers to create summaries that contain important propositions and omit trivial ones (Anderson, 1978).

In summary, schemata and schema-based processes (e.g., ideational scaffolding, attention allocation, inferential elaboration, inferential reconstruction, searches of memory, editing, and summarizing) facilitate comprehending, learning, and remembering.
That is because readers’ schemata that readers possess provides an expansive and interpretative framework for comprehending and remembering discourse. How well readers comprehend text is contingent on whether they have appropriate schemata for what they are reading and whether the reading materials effectively evoke readers’ schemata. In the next section, studies that show how schemata facilitate readers’ learning, comprehending and remembering will be reviewed.

*Empirical Findings*

In this section, the studies based on schema theory will be reviewed. First, the studies that have focused on how the schema-based processes facilitate learning and remembering will be described. Also, how schemata affect encoding and retrieval differently depending on when the schema is activated will be looked at. Finally, the studies regarding how readers’ expertise, culture and situational context evoke their schemata and influence their interpretation, encoding and recall of the passage will be discussed.

Anderson, Spiro, and Anderson (1978) showed that particular information was better remembered when the components of discourse match with readers’ schemata. In their study, 75 undergraduate students were randomly divided into two groups and read one of two passages. One was about dining at a fancy restaurant and the other about trip to a supermarket. The students who read the restaurant passage showed better recall of food items that fits with a restaurant schema such as salad, drink and entrée, but no better recall of the items from the low-probability category. The researchers suggested that the same information was better encoded in the situation of eating at a fancy restaurant because the restaurant schema most closely fit the text information about food items and
orders. In other words, the restaurant schema already had slots that are easily filled by the information about food items, orders and attribution to a character, which is *ideational scaffolding*, and accordingly, the information was more effectively encoded and learned.

In Pichert and Anderson’s (1977) study, the participants were asked to take one of three perspectives—a home buyer perspective, a burglar perspective, or no perspective—and then read a story about two boys playing hooky from school. They recalled more information that was consistent with their perspectives than the information that was not related to their perspectives. The findings were explained in terms of the influence of schemata on readers’ decision about what details are important. That is, the schema of home buyer or burglar helped the readers be more attentive to the information that was consistent with the perspective assigned. Therefore, information congruous with their respective perspectives was better encoded and learned and better remembered later.

Anderson and Pichert (1978) also conducted a study to investigate the effect of changing perspective. In this study, the subjects were asked to read the passage identical to one in their previous study with the perspective assigned, but were requested to recall the passage twice. Before the second recall, half of the subjects were instructed to take a new perspective, for example, from home buyer to burglar. The result revealed that the subjects recalled additional information important to the new perspective but unimportant to the original perspective. This strongly supports an argument that the new schema lead to searches for important elements consistent with it and to editing and summarizing them. That is, retrieval processes also are facilitated by a guide of schema. However, what was not clear in those studies is how the time when a reader employs a schema has different effects on encoding and retrieval.
To clarify this issue, Anderson, Pichert, and Shirey (1983) investigated the time course of schema effects—before reading, right after reading, and long after reading. 57 female and 14 male college sophomores, juniors, and seniors participated in their experiment 2. They were assigned one of two perspectives—burglar versus home buyer—before reading the story about two boys playing hooky from school. Right after reading, they were cued to recall it from one of two perspectives. Groups were randomly selected and asked to recall the text either with the same perspective earlier taken at the time of reading or from the different perspective. About two weeks later, the subjects were asked to recall the passage again. Half of the subjects were asked to recall the text from the original perspective assigned when they read the story and the rest requested to recall from the other perspective, which was different from their reading perspective.

In general, the subjects recalled additional information that was not important for their original perspective but important for their new perspective. Right after reading, most subjects (87%) recalled at least one additional piece of information that was important to the new perspective but not important to their reading perspective. Two weeks after reading, half of the subjects also recalled new information that was consistent with their new perspective. The researcher concluded that the schema operating during recall enhances the probability of remembering the information that was not important for their reading perspective but important to their recall perspective. Thus, the schema operative during recall can provide a structure that facilitates an orderly search of memory and provides the criteria for editing unimportant or uncertain information.

It seems also that schemata employed at the time of reading can enhance encoding. This assertion can be supported by the finding that the recall of information, which was
important to the reading perspective but unimportant to the recall perspective, was still prior to the recall of information unimportant to both the reading and recall perspective. The information important to the reading perspective was allocated more attention and so was better recalled than the information unimportant to both reading and recall perspectives. This can be explained only in terms of an encoding process. Consequently, the results show that the perspective before reading the passage enhances encoding whereas a perspective taken after reading enhances retrieval. When the reading perspective and the recall perspective are the same, the information that is important for the perspective is doubly enhanced by both encoding and retrieval processes.

The previous studies examined the role of a schema by assigning the readers into different roles such as burglar versus home buyer. Some studies, however, employed passages designed to arouse readers’ expertise and their different cultural schemata. Other studies provided different situational contexts and investigated how they aroused readers’ schemata and how they played a role in the readers’ comprehension. Those studies will be reviewed below.

Readers’ expertise enables them to construct schemata relevant to their experiences. The schemata in turn enable readers to see things in a certain way. The study by Anderson, Reynolds, Schallert, and Goetz (1977) revealed the important role of schemata in text comprehension by showing that readers’ expertise evokes their schemata and enables people to see a same message in different ways. In this study, it was shown that meaning of words in a sentence depends on the interaction between individual’s word knowledge based on their expertise and context. Thirty female students planning a
career in music education and thirty male students taking weight-lifting class in physical education participated in this study.

The subjects read the same passages, but ones could be interpreted in two different ways. The first passage could be interpreted as about a convict planning his escape from prison or about a wrestler trying to break the hold of an opponent. The second passage could be interpreted as being about friends’ playing cards or about a rehearsal session of a woodwind ensemble. Thirty female students from music education interpreted the first passage as about prison context, which is a general perspective people usually possess, but the second passage as about a music context, which was not the common perspective but the perspective specific for people with music expertise. In contrast, thirty male students from physical education interpreted the first passage as about a wrestling context, which is not the general perspective but the specific one for people who had wrestling expert knowledge, and the second passage as about playing cards, the common perspective. The results demonstrated that people who have a different knowledge structures due to different expertise, different world beliefs, and their different backgrounds will interpret the same, identical passage in different ways.

A number of studies have showed the importance of readers’ cultural schemata in comprehending discourse (e.g., Pritchard, 1990; Reynolds, Taylor, Steffensen, Shirey, & Anderson, 1982; Steffensen, Joag-Dev, Anderson, 1979). The text written with culturally familiar context for readers was more effectively understood and remembered because the text easily evokes readers’ relevant schemata or background knowledge. However, the text that did not provide familiar cultural context was highly misunderstood and distorted.
A study by Reynolds and his colleagues investigated the importance of cultural schemata in text comprehension by employing an instance of sounding (Reynolds, Taylor, Steffensen, Shirey, & Anderson, 1982). *Sounding* is the activity in which black male adolescents engage to gain the group’s favor by means of insults at close people or making derogatory allusions to their poverty, physical attributes, or sexual behavior. The result reveals that white and black subjects had different interpretations about what was described in the passage they read in the experimental passage. Many white students considered the event as a fight whereas most black students interpreted the episode as ritual insulting. In general, the white students tended to misinterpret the story due to their different cultural background.

A study by Pritchard (1990) showed that students tend to employ different strategies depending on the situation in which they read a culturally familiar or unfamiliar text. In his study, thirty American and thirty Palauan 11th grade students read two letters that a woman wrote to her sister to describe the events regarding funerals in each culture. According to the result, the subjects used *developing awareness* (the subject’s growing awareness of how much progress they were making and how many problems they encountered during reading) and *establishing intrasentential ties* (the subject’s attempting to understand a certain sentence without connecting it to their background knowledge or other sentences in the passage) significantly more often when they read the culturally unfamiliar passage than when they read the culturally familiar passage. This is because that they found it difficult to connect the stimulus sentence to other part of text or to their background knowledge. In contrast, *establishing intersentential ties* (the subject’s trying to understanding a sentence by relating it to the other sentences in the passage) and
**using background knowledge** (the subject’s effort to understand the stimulus sentence by using their background knowledge) were significantly more used for the culturally familiar passage than for the culturally unfamiliar one. Pritchard also found that more elaborations occurred in the culturally familiar passage and more distortions appeared in the culturally unfamiliar passage. These findings suggest that readers employ different strategies when they read culturally familiar and unfamiliar text, and that relevant cultural schemata facilitate the reading process.

Context plays a role in evoking the reader’s schemata as well. The more familiar context was better recalled because the familiar context is more likely to arouse a reader’s schemata. As a consequence, schemata play an important role in remembering the text content (Freebody & Anderson, 1983). Various studies have shown that context is helpful for understand text being read (Carey, Harste, & Smith, 1981), finding word meanings (Anderson, Stevens, Shifrin & Osborn, 1978; Nagy, Herman, & Anderson, 1985) and enhancing encoding and retrieval (Freebody & Anderson, 1983).

Carey, Harste and Smith (1981) examined the effect of situational context on interpreting the text by replicating the study by Anderson, et al. (1977). The researchers had judged that the result of the original study did not clearly reveal whether the different interpretations about the same passage were due to their different background knowledge and expertise (majoring in music education or physical education), or the situational contexts (taking the test in an educational psychology course or in weight-lifting classes) because the subjects’ background knowledge and situational context were confounded. In the study, the researchers added one more condition that excluded a situational context. The students in the *Situationally Constrained Group* (music major students in music class)
exhibited greater background knowledge when they interpreted the same passage than the students in the *Situationally Less Constrained Group* (music major students in English class). This study reveals the important role of context in evoking schemata and the role of evoked schemata in making the students see the passage in a certain way.

In summary, schemata are knowledge structures that facilitate encoding by generating more attention to certain information, providing ideational scaffolding, and facilitating referential elaboration. Similarly, retrieval processes are carried out more smoothly through their offering criteria for importance and enabling editing and summarizing using referential reconstruction when there is gap in memory. Enhanced encoding and retrieval processes also facilitate comprehending discourse. If texts do not induce appropriate schemata or readers do not have appropriate schemata, comprehension will be hampered.

**The Effects of Context**

Context refers to the part of a discourse that is adjacent to a target word or a passage, or the set of facts and circumstances that surround a situation or event. Because context helps the meaning in reading materials to be clear, word recognition as well as text comprehension cannot be accomplished without utilization of contextualized knowledge about words, sentences, and their meanings (Bruning, Schraw, Norby, & Ronning, 2004). Due to the fact that the right contextual information facilitates the readers to draw the necessary relations from concepts in the succeeding words and sentences, it is important to provide appropriate context that assists readers to achieve an accurate word identification, to learn new vocabulary, and to understand reading materials correctly (Schwanenflugel & Shoben, 1983).
The research examining context effects is highly varied, focusing on a variety of contexts and outcomes that have included word identification and word recognition (e.g., Kim & Goetz, 1994; Kintsch & Mross, 1985; Stanovich & West, 1981), lexical decision (e.g., James, 1975; Kleiman, 1980; Meyer & Schvaneveldt, 1971; Schuberth, & Eimas, 1977; Schvaneveldt & Meyer, 1973), new vocabulary learning (e.g., Beck, McKeown, & McCaslin, 1983; Herman, & Dole, 1988; McKeown, 1985; Nagy, Herman, & Anderson, 1985), and reading comprehension (e.g., Bransford & Johnson, 1972; Carey, Harste, & Smith, 1981; Jenkins, Fuchs, Broek, Espin, & Deno, 2003).

In those studies, the scope of context varied from a single word (Meyer & Schvaneveldt, 1971) to culture (Steffensen, Joag-Dev, & Anderson, 1979). The specific meaning of context was usually defined in a study such as words, sentences and paragraphs. Surprisingly, however, a broader meaning of context has been used implicitly. Butterworth (1992), for example, explained how the context has tended to be defined generally as “a common sense approach focusing on the physical, social or cultural setting of a particular intellectual task” (p.6). From this broader perspective, what counts as context for learners is whatever they consider relevant. From this point of view, context can comprise the way how a reading material is presented, an individual’s various characteristics such as his/her prior knowledge, and broadly, social and cultural factors. Context also can be defined more in the abstract, for example, with context referring to the “…interconnected whole that gives meaning to the parts” (Butterworth, 1992, p.6). That is, words, sentences, paragraphs, a whole story, settings, and culture can be considered as context. A variety of studies conducted to examine the effects of context will be reviewed in detail in the following part.
Empirical Findings

*Context effects on word recognition and lexical decisions.* In the body of research focused on the effect of context on lexical decision and word recognition, the scope of context varies from offering a single word to presenting sentences. Regardless of the different contextual settings, context has been shown to facilitate word recognition and lexical decision in most studies.

To examine the effect of single word context on lexical decision in many studies, subjects often are asked to decide whether or not two strings of letters form words. Two strings of letters can be offered simultaneously or one string of letters shown prior to the target string of letters. Meyer and Schvaneveldt (1971), for example, provided two strings of letters simultaneous and asked the subjects to decide whether or not both strings of letters form words. The reaction time was significantly faster for associated pairs than for unassociated pairs. This showed a single word context facilitates lexical decision when the preceding word was associated with the target word. Further, an associated word context effect was examined under the condition in which an unassociated word was inserted between two associated words (Schvaneveldt & Meyer, 1973) and in which non-words was presented (James, 1975). In all of those studies, the effect of a single word context was confirmed by showing facilitation of word recognition.

In contrast to the single word used to provide context in the above studies, other studies focused on the sentence frame context provided a sentence to the subjects to examine the effect of the sentence context on word recognition or lexical decision. Kleiman’s study (1980), for example, demonstrated that the sentence frame contexts facilitated the subjects’ lexical decision for the best completion words, the reasonable
completion words, and the related words by showing shorter reaction time and fewer errors on those words. In another study, lexical decision was facilitated by context differently depending on the characteristics of words (concrete vs. abstract). Providing sentence context leads to shorter lexical decision time for abstract words while lexical decision time was not different for concrete words with or without sentence context (Schwanenflugel & Shoben, 1983). The scholars provided rationale that contextual information is already accessible for concrete words, and thus, adding sentence context contained little value to shorten lexical decision time.

A context effect on lexical decision time also was obtained in the study by Schuberth and Eimas (1977). In the study, the subjects were requested to classify a string of letters into words or non-words when they were exposed to the three different conditions: (a) a target letter string was offered after an incomplete sentence, or (b) after a string of four spelled-out digits, or (c) only a target letter string was presented. The reaction time for the incomplete sentence context was significantly faster than four spelled-out digits context or no context. That is, the incomplete sentence context more facilitated lexical decisions for incongruous and congruous words than the no context or the four spelled-out digits context. Specifically, the reaction time was significantly faster for the congruous words than incongruous words and this showed that providing incomplete sentence context was more effective for congruous words.

Other scholars examined the sentence context on word recognition more in detail. Kintsch and Mross (1985) showed that word identification comprises two different phases, sense activation and sense selection. When the test words were provided right after the test sentences, word identification was influenced by associative context but not
by thematic context. That is, under the sense activation condition, the subjects heavily relied on the association strength between the priming words and the test words regardless of thematic context. However, when enough time was offered to the subjects before presenting the test words, the lexical decision task was sensitive to thematic context. Therefore, the experiments demonstrated that word identification is differently affected by context depending on whether the phase is sense activation or sense selection. Also, they clearly showed the effect of associative context and thematic context has different effects on word identification.

In a study by Stanovich and West (1981), a sentence context effect on word identification also was demonstrated. The subjects were asked to read the target words under congruous-context, incongruous-context and neutral-context conditions. The reaction time for the target words under congruous-context was faster than incongruous or neutral-context. Also this context facilitation effect was larger for difficult words than easy words. The researchers explained that because the process of recognizing difficult words is slower than one for easy words and thus, more time generated by slower recognition leads to more effective facilitation of contextual information.

Sentence context was manipulated by varying sentence orders (original sentence order vs. scrambled sentence order) in the research of Kim and Goetz (1994). In those different sentence contexts, the target words were presented with original forms or altered forms. The results showed that scrambled sentences provided limited contextual information due to the difficulty in integrating the whole information. The results also showed that poor readers read more the original words than the altered words in the original sentence order context than good readers did. This demonstrated that poor
readers more rely on contextual information to facilitate word recognition while good readers utilize orthographic information more to do that. This is because poor readers try to compensate their limited reading ability by counting on contextual information.

In summary, many studies have shown that the single word context and the sentence context smooth the progress of word recognition or lexical decision. Especially, context facilitates more effectively when difficult words are shown and poor readers read. According to Kintsch and Mross (1985), if more time is given, sense selection is taken over and the effect of context will be larger. Based upon the statement, the larger context effect for poor readers and difficult words can be explained by the same reasoning.

*Context effects on learning new vocabulary.* A body of research investigated the effect of context on vocabulary learning (e.g., Cain, Oakhill, & Lemmon, 2004; Carnine, Kameenui, & Coyle, 1984; Nagy, Anderson, & Herman, 1987; Stahl, & Fairbanks, 1986; Swanborn, & Glopper, 2002). In those studies, context usually refers to text in which an unknown word is embedded. Researchers generally acknowledge that context is beneficial to grasp the meanings of new words because working within contextual limits enable readers to take accurate information about potential word meaning from it.

According to McKeown (1985), there are three phases in the process of gaining word meaning from context: “selecting constraints from context, taking advantage of multiple contexts, and using new words following initial learning” (p.494). To learn new words, readers need to know how the words’ meaning adapts to different contexts. This involves exposure to the words in multiple contexts from different perspectives. However, literature suggests that the degree of learning new vocabulary from context is also affected by kinds of context, reader’s age and ability, reading purpose, and text variables.
Broadly, two different kinds of context can be distinguished in vocabulary learning: one is pedagogical and the other is natural. Pedagogical contexts are distinctly constructed for teaching new words whereas natural contexts are the large group of words surrounding the unknown words in normal reading materials (Beck, McKeown, & McCaslin, 1983). Thus, pedagogical context is more effective in learning new vocabularies than natural contexts. The text materials in the research of Jenkins, Stein, and Wysocki (1984), for instance, were written for the study and they were more informative about the unknown words than natural reading materials. Their result was more favorable of learning new words from context than another study that employed natural texts (Nagy, Herman, & Anderson, 1985).

Natural contexts can be distinguished into four types according to the characteristics of context: misdirective contexts, nondirective contexts, directive contexts and general contexts (Beck, McKeown, & McCaslin, 1983). Misdirective contexts refer to those that are likely to direct readers to an incorrect meaning for an unknown word while nondirective contexts indicate those that are not helpful for providing a particular meaning for an unknown word. Directive contexts guide readers’ attention to a correct meaning but those are not intended by the author, which is different from pedagogical contexts. General contexts contain enough information that helps readers grasp meanings roughly. Therefore, pedagogical contexts and directive contexts are the most conducive to learning new words.

The effect of context on learning new vocabulary varies depending on readers’ characteristics. When readers are older (Carnine, Kameenui, & Coyle, 1984) and they have larger vocabularies (McKeown, 1985) and good comprehension skills (Cain,
Oakhill, & Lemmon, 2004; Swanborn, & Glopper, 2002), they benefit more from context in learning unknown vocabulary words. Additionally, the likelihood of learning word meanings from context depend on the level of readers’ prior knowledge and the level of ability to weed out irrelevant information and to integrate information surrounding the unknown words (Sternberg & Powell, 1983).

The purpose of reading also affects vocabulary learning from context. Swanborn and Glopper (2002) found that readers learn new vocabularies from context more when they read to learn about the topic or for text comprehension than when they read in free reading condition. This is because readers invest more effort when they are requested to read for learning about topic and achieving text comprehension. Those situations assist the readers in more focusing on new words and finding out meanings from context, and lead to higher learning outcomes.

Text variables also affect readers’ ability to extract word meanings from context. Those are the distance between the target word and its cue, the way how to connect between them, and the form of the contextual information in a passage. The more the distance between the context clue and the unfamiliar word is close, and the connection between them is explicit, the more context clues serve the reader advantageously. Also, readers profit more from context clues when they are in synonyms (Carnine, Kameenui & Coyle, 1984). Other variables identified by Nagy, Anderson, and Herman (1987) are kinds of text (expository vs. narrative), and conceptual difficulty of unfamiliar words. Their study found that the conceptually most difficult words are not likely to be learned from context and contextual support for new vocabularies is likely to be useful only in expository text not in narrative text.
In summary, researchers generally acknowledge that context assists the progress of new word learning by assisting readers in grasping the meanings from the context. However, many studies have shown that learning new vocabulary from context relies on several factors. In order to maximize effects of context on learning new vocabulary, such factors as kinds of context and text, text variables (the distance between unknown words and the cue sentences, the way how to connect two, the form of the contextual information), and the characteristics of readers (age, background knowledge, reading comprehension skill, and vocabulary ability) should be considered.

*Context effects on reading comprehension.* Context facilitates comprehension processes by adding contextual information to the reading materials (Bransford & Johnson, 1972). As addressed previously, context broadly refers to the set of facts or circumstances that surround a situation or event such as settings and culture, and narrowly refers to the part of a discourse that is adjacent to a word, a sentence, a passage and a paragraph in the materials to be read. Reading comprehension is more likely to be influenced by the broad meaning of context than the narrow meaning of context. In the study by Jenkins, Fuchs, Broek, Espin, and Deno (2003), the relationship between context and reading comprehension was examined by context fluency. Context fluency scaled by reading speed and reading time of one folktale presented in its natural format strongly predicted reading comprehension. When the words in the story was randomly ordered in paragraphs without punctuation or when the words in the folktale were randomly presented in a list, reading fluency (reading time and reading speed of two conditions) were not a strong predictor for reading comprehension. The results
demonstrated that contextual information plays an important role in predicting reading comprehension.

In a well known study by Bransford and Johnson (1972), context for a written passage was provided in the form of a picture, which offered important information about what was going on in the passage. The result clearly showed that presenting the appropriate knowledge before reading had a marked effect on comprehension and recall. In a second study, the topic of a passage was provided in three different conditions (No topic, topic before reading, and topic after reading). They found that providing a topic before reading was most facilitative, having a significant role that appeared to help subjects create context being used to comprehend the passages in the first place. The condition of topic before reading was set up to evoke the readers’ prior knowledge and to provide context and as expected, readers’ understanding were better than that in the other two conditions.

Environments or settings in which reading takes place also provide contextual information by assisting readers in drawing the necessary relations between concepts in the text and the environments. Those environments and settings can also affect reading comprehension. For instance, in Carey et al’s (1981) study, physical education students in a physical education class more often interpreted the ambiguous prison/wrestling passage as wrestling sequence than the physical education students in an English class. Likewise, the music major students in a music class more construed the vague cards/music passage as music sequence than the music major students in an English class. These studies illustrate that the situational context in which the print is encountered is prominent in text processing and is an important factor influencing reading comprehension.
Likewise, the cultural background of reading material serves as context for readers by evoking their cultural knowledge. When the cultural background of the material does not consist with that of the reader’s, reading comprehension will be impaired. One classic study supports this. Two different contexts for a wedding, which were Indian and American setting for the wedding, strongly affected readers’ reading comprehension (Steffensen, Joag-dev, & Anderson, 1979). American students recalled more details for the American wedding passage while producing more distortions for the Indian wedding text. Indian students showed in the same effects, but in the opposite direction. This study was originally conducted to examine the effect of schemata on reading comprehension but here, the study is recapitulated to illuminate the effect of different cultural context on reading comprehension.

Likewise, Johnson (1981) showed that the cultural origin of the story (Iranian folklore vs. American folklore) had an effect on reading comprehension measured by recalling the story and answering multiple choice questions. When students read the story that matched their cultural origin, their reading comprehension was boosted. The same results were obtained for students who had same cultural origin but with different sub-cultural backgrounds (Chan, 2003). The study demonstrated that students from Hong Kong and students from mainland China showed the different level of comprehension about the reading material (the Symbols of Hong Kong) that reflected sub-cultural backgrounds of Hong Kong. Even though the two groups of students share Chinese culture in general, the cultural context of the Symbols of Hong Kong passage was not enough to evoke students’ cultural background from mainland China and consequently, their comprehension was hampered.
So far, the effects of context on word identification, lexical decision, vocabulary learning and reading comprehension have been examined with a variety of studies showing that context facilitate a range of reading from word recognition to comprehension. These studies also show how important a wide range of contexts can be for learning and recall in a variety of tasks. We now turn to studies on the effects of signaling.

The Effects of Signaling

Signaling usually refers to the addition of noncontent words to written texts that emphasize certain aspects of the semantic content, or accentuate the conceptual structure or organization of the passage (Loman & Mayer, 1983). In other words, signaling is aimed at guiding learners’ effective cognitive processing but is not intended to offer substantive or novel information (Mautone & Mayer, 2001). Signaling assists readers in allocating their mental resources to important aspects of content or structure as well as in figuring out which information is relevant and important. Furthermore, signaling helps optimize learners’ cognitive load by guiding learners’ attention to significant content and organizational features. As a result, learning is more likely to be improved. The effect of signaling is examined and described in more detail below.

The Effects of Signaling in Written Text

Various types of signals exist in written text: *title and headings* that guide the reader to the most relevant information in the text, *previews* that provide overall content before the actual content, *logical connectives* that make relationships between ideas clear by linking subordinate pieces either with other subordinate pieces or with superordinate pieces, *pointer words* that show a writer’s view of content, *summary statements* that
pinpoint important aspects one more time after the content, and *typographical cues* such as boldface, italic, and indentation that are used to draw readers’ attention to a certain text features (Lorch 1989; Spyridakis & Standal, 1987). Researchers have examined how these signaling devices influence attention, recall and comprehension during reading.

Signaling aims to guide readers’ attention to particular information that is important in a text and assist them in discriminating important information from unimportant information during reading. How readers’ attention is affected by signaling has been investigated indirectly by whether readers recall signaled content more, and directly by recording reading speed on signaled information in a text. It assumed that more attention is allocated if readers recall a specific part of information (signaled content) or more accurate information. Likewise, if subjects read a specific part of text more slowly than other parts in text, it was assumed that readers focused more on that information. Generally, studies found that more attention was paid when signaling was offered (e.g., Lorch & Lorch, 1985; Lorch, Lorch, & Inman, 1993).

Signaling also leads to better recall performances in general because it guides readers’ attention and help the readers distinguish a specific part of text from the rest and consider that important. Lorch and Chen (1986) showed the positive effect of signaling on recall. When the sentences were signaled, subjects recalled the target information more closely to the original text. However, other studies reveal that signaling do not increase recall performances in all occasions (e.g., Brooks, Dansereau, Spurlin, & Holley, 1983; Healy, Fendrich, Cunningham & Till, 1987; Spyridakis & Standal, 1987). In those studies, the recall of topics, the topic organizations and overall recall were influenced by
certain text characteristics such as the complexity of topic structure and by the time when signals are provided.

In addition, signaling assists readers in comprehending what they read more effectively. Good comprehension depends on how well readers form a coherent representation that includes hierarchical retention of superordinate content, integration of content and formation of inferences. Signaling is helpful for readers to select relevant information and organize the information into a coherent representation. Therefore, readers’ comprehension can benefit from signaling. In the absence of signaling, readers are less likely to distinguish important information and form a coherent representation. Thus, their comprehension is more likely to be poor. How readers’ attention, recall and comprehension are affected by signaling will be examined below through reviewing studies.

*Empirical Findings*

*Attention.* Studies have shown that signaling assists readers in allocating their attention to signaled parts. Lorch and Chen (1986), for example, showed signaling attracts more attention to the signaled parts. In the study, it was demonstrated that readers focused more on signaled sentences by showing readers read signaled parts more slowly than unsignaled ones. Another study (Britton, Glynn, Meyer, & Penland, 1982) revealed that signaling frees cognitive capacity as well as attracting more attention. That is possible because signaling leads attention to only important elements.

In Britton et al’s study, how signaling affected attention was examined by adopting a secondary probe task. The primary task was reading and the secondary task was reacting to sporadic and unpredictable clicks. It was assumed that if more attention is
being devoted for reading, less capacity is available for the secondary task and thus, reaction time to the click will be slow. Four different kinds of signals were adopted in their third experiment: signals that point out relations among text ideas, previews, summaries, and signals that identify the most important ideas. The result revealed that average reaction time for the secondary task was faster when signaling was provided than absent. This suggests that signaling is effective to reduce cognitive processing capacity by helping readers pay attention to only significant components, construct an internal representation of text content effectively, and infer the ideational relations needed in building internal representation. According to the two studies above, signaling is effective in collecting readers’ attention and in reducing cognitive processing capacity.

*Recall of topics and topic structures and recall of overall text.* There are ambivalent results about the effects of signaling on the recall of topic and topic structures and recall of overall text. The recall of topics and topic organizations were benefited from signaling its structure. Subjects in the signaled condition recalled more text topics and demonstrated better memory for the organization of the topics (Lorch & Lorch, 1985; Lorch, Lorch, & Inman, 1993). Researchers, however, found under a certain condition, the recall of topics was not more effective in the signaled condition than the unsignaled condition. If text topic structure is very simple, readers can construct complete and coherent topic structure representations without the presence of text structure signals. In that case, readers do not need the help of signals in constructing a topic structure representation because there are only few topics and the topics are well developed and easily related each other (Spyridakis & Standal, 1987). Thus, signaling is not likely to be
effective in improving the recall of topics and topic structures in the simply-structured text as much as it is in the complex text.

Also, there have been contrasting results regarding the effect of signaling on overall recall. Several studies have failed to demonstrate signaling effects on overall text recall (e.g., Brooks, Dansereau, Spurlin, & Holley, 1983; Lorch, Lorch, & Inman, 1993). For example, Lorch, Lorch and Inman (1993) employed topic structure signals such as an overview of upcoming topics, a summary and headings. They observed that signaling topic structure guided subjects to focus more on topic information whereas that resulted in poorer memory of subordinate information. Accordingly, the result led to no effect on total recall. They concluded that signals that give emphasis to text structure and organization are likely to distract the reader’s attention from subordinate content and thus, lead to poorer recall of subordinate content.

No signaling effect on overall recall was found by Lorch and Lorch (1996) in the half-signals condition (Experiment 3). Unsignaled content in the half-signals condition was recalled more poorly than the corresponding content in the no-signals condition. This showed that recall for the unsignaled content in the half-signals condition was hindered by the presence of signals. Therefore, organizational signals lead to better recall for text topics and organizations and better recall for signaled content, but poorer recall for the subordinate content about unsignaled topics. These ambivalent results lead to no effect of signaling topic structure on overall text recall.

However, some studies have shown an increase of overall recall in certain conditions. In the second experiment of Lorch and Lorch’s study (1996), overall recall was increased in complex topic structure condition. When topic structure was relatively
complex and difficult, students in the signals condition recalled more subordinate content than students in the no-signals condition. Also, the study by Rickards, Fajen, Sullivan and Gillespie (1997), overall recall was increased by signaling in only the listening context but not in the reading context. The subjects in the listening context did not have any control over pace and little chance to review a particular section and this situation gave them more demand on working memory. Signaling in that situation effectively guided the subjects’ attention to the relevant idea units and effectively reduced extraneous load. As a result, the overall recall was increased as well. Overall recall, thus, is likely to depend on the characteristics of text and condition. In summary, even though signaled part are better recalled in general, overall recall and the recall of topics or topic organizations have been observed in two ways depending on text characteristics (e.g., simple vs. complex structure) and conditions (e.g., listening vs. reading).

Comprehension. Effects of signaling on comprehension have been examined by problem solving task or making inference problems. In Loman and Mayer’s study (1983), signaling encouraged readers to use meaningful reading strategies. As a consequence, readers were more capable of solving creative problems and generating high quality answers. Also, Spyridakis and Standal (1987) demonstrated that signals such as headings, previews, and logical connectives help readers figure out superordinate content and make inferences

In another study, it is shown that signaling the key causal links of the system enhanced subjects’ creative problem-solving performance (Mayer, Dyck, & Cook, 1984). In their second experiment, 30 college students read three different version of a passage about nitrogen cycle: the first version was the control version taken from a high school
biology textbook, the second one was the signaled version that included additional previews and headings, and the third version was the signaled-enhanced version that was identical to the signaled version except adding five new paragraphs to clarify the key causal links. The results showed that students’ problem solving performances were enhanced because the signaled and signaled-enhanced group generated significantly more good answers (relevant and actually possible answers) than the control group. This reveals that signals help students build a more coherent representation and enhance their comprehension.

However, the signaling effect on understanding also depends on the characteristics of text. Spyridakis and Standal (1987) examined the effects of three types of signals (heading, previews and logical connectives) on comprehension of technical expository prose. About 300 college-level students read one of four passages and the passage was written with eight different versions (one was non signaled version and seven were differentiated by the combination of three signals). When a passage was easy enough to the students, then signals were of little value whereas when detail content was difficult and the load was heavy, signals, such as headings and logical connectives, were most effective to improve readers’ understanding (Spyridakis & Standal, 1987). Therefore, the characteristics of text need to be also considered to investigate the effect of signaling on comprehension.

*The Effect of Signaling in Multimedia Learning*

Even though the effects of signaling in printed passages have been examined by various studies for an extended time (e.g., Lorch, 1989; Lorch & Chen, 1986; Lorch & Lorch, 1985), researchers started to investigate the effects of signaling in multimedia
learning recently. Multimedia learning is defined as “learning from words and pictures” and multimedia instruction is defined as “presenting words and pictures that are intended to foster learning” (Mayer & Moreno, 2003, p. 43). One example of multimedia instruction is a computer-based narrated animation explaining causal relationships in the learning material.

Signaling in multimedia learning is also used to guide the learner to what to attend and how to organize it. The theoretical rational of signaling is same as one in the written text, which is that signaling directs learners’ attention toward relevant learning material, thereby helping the learner ignore irrelevant material and use all cognitive source to process important material. In other words, signaling directs learner’s attention toward essential information and prevents using unnecessary mental resource for processing of extraneous information. Thus, the learning outcome is improved by including signaling in multimedia learning (Mayer, 2005) as well. How same signaling devices in written text and visual cues are used effectively in multimedia learning environments will be reviewed below.

*The effect of signals in written text on multimedia learning.* A study regarding whether signaling effects in written text can be implemented to multimedia learning was conducted by Mautone and Mayer (2001). In their study, signaling refers to “cues to the learner for how to process the presented material” (p. 377). To explore the effects of signaling in multimedia learning, they employed the signals used by previous research for written text such as headings, summary, connecting words and using bold face or italic type. The subjects who received the version of signaled narrated animation (signaled narration and signaled animation) performed better on problem-solving transfer test than
the subjects who didn’t receive any kind of signaling (Experiment 3). This result demonstrated that students comprehend a multimedia presentation better when it includes signals helping them how to process the material than when it does not.

**Visual cues.** A large number of studies have shown that signaling can be very effectively used to reduce efforts for visual search in multimedia learning (e.g., Jeung, Chandler, & Sweller, 1997; Kalyuga, Chandler, & Sweller, 1999; Tabbers, Martens, & van Merrienboer, 2004). For instance, Kalyuga et al. (1999) found that one of visual cues, color coding was effective to create a link between textual and pictorial information and as a result, learning outcomes were enhanced by reducing unnecessary search.

Also, visual cues were successfully used to enhance performances in the study by Koning, Tabbers, Rikers, and Paas (2007). When students studied using animation regarding how cardiovascular system works, attention was guided to the relevant aspects in the animation by visually cueing the valves of the heart. The results showed that working memory resources can be allocated efficiently to learning itself by adopting the visual cues. Additionally, the results on the transfer test suggest that cueing helps learners understand the content effectively and form more coherent schemata. These findings broaden the effect of visual cueing revealed by the previous research. Visual cueing, however, is less effective when it is used to animations that include any narrations. Specifically, it is more effective when visual cueing is presented in animation without narration and when it is used for text (Lorch, 1989; Lorch et al., 1993) or the combination of pictorial and textual information (Kalyuga et al., 1999).

These results suggest that students learn better from multimedia messages when cues emphasizing the organization or the important information are presented. In general,
when a multimedia message contains cues such as an outline, headings and visual cues that are used to highlight important material, this approach is likely to be effective for improving learning outcomes. However, the studies that have been conducted to examine the effects of signaling in multimedia learning are limited. The results reported here are promising but more research is needed to establish the strength and robustness of signaling effects on multimedia learning.

The benefits from signals in text and multimedia learning are closely tied to the fact that people have limited cognitive resources. Signaling helps readers use fewer mental resources for selecting relevant material, which leaves more resources available for the higher process of organizing and integrating of the information. Well-designed signals can help learners construct, organize and integrate information to be learned more effectively and as a consequence, learning outcomes such as recall and understanding can be improved. However, text characteristics and conditions need to be carefully considered to optimize signaling effects.

Cognitive Load Theory

Cognitive load theory (CLT) has been utilized to increase the effectiveness of learning and decreasing unnecessary effort that is not directly related to learning itself. Researchers have attempted to find better instructional methods that help learners fully invest available cognitive resources in learning. By modifying instructional designs in various ways, researchers have tried to find better instructional methods in many fields, such as science (e.g., Lee, Plass, & Homer, 2006), mathematics (e.g., Owen & Sweller, 1985; Sweller, 1988; Sweller & Cooper, 1985), training programs (e.g., Chandler & Sweller, 1991; Chandler & Sweller, 1996; Paas & van Merriënboer, 1994a) and
multimedia instruction (e.g., Kalyuga, chandler, & Sweller, 1999; Mayer & Moreno, 1998; Mayer, Moreno, Boire, & Vagge, 1999). As a result of a variety of instructional methods based on CLT, learning outcomes have been enhanced.

CLT will be reviewed in detail below. First, theoretical perspectives on CLT will be provided by addressing the components of CLT and its assumptions. Next, based upon empirical findings, instructional methods that have proved effective for better learning will be illuminated. After that, the different ways to measure cognitive load will be reviewed. Finally, how CLT was adapted to this study is addressed.

*Theoretical Perspective on Cognitive Load Theory*

*Limited working memory and unlimited long-term memory.* CLT has several assumptions consistent with those of the information processing model. Among these assumptions are limited working memory and unlimited long-term memory, which are the building blocks of cognitive load theory. Working memory is able to hold only about seven items or elements of information at one time (Miller, 1956). Mental work can be performed without taxing the resources of working memory under normal information processing loads, but when the processing loads exceed the capacity of working memory limitation, intellectual work cannot be conducted effectively. Cognitive load theory accepts the capacity limitation of working memory but also emphasizes that the limitation only applies to novel information (Bruning, Schraw, & Norby, 2011). When working memory deals with information stored in long-term memory, it does not have any restrictions. Thus, CLT has dealt with how to reduce working memory load when an individual learns new material (van Merriënboer & Sweller, 1991).
CLT also assumes an unlimited capacity for long-term memory, and the important roles of meaning and organization in long-term memory. In long-term memory, knowledge is structured into complicated representations called schemata (Anderson, 1978). Schemata can operate like a central executive that organizes information and knowledge and help a new material processed in working memory. Under the circumstances in which schemata act as a central executive, working memory load can be largely decreased (van Merriënboer & Sweller, 2005). Thus, CLT focuses on the fact that schemata greatly reduce working memory load. When readers employ appropriate schemata, even highly complicated information can be managed as one element.

Schema automation also enables learners to bypass the limited working memory through allowing cognitive processes to occur without conscious control. After considerable time and practice, a schema can be automated and one can recognize the category of the problem with minimal demands on one’s limited processing capacity (Sweller, van Merriënboer, & Paas, 1998). Both schema construction and automation that use information stored in the long-term memory can greatly reduce the burden on working memory and thus, achieving schema construction and automation are very significant in CLT to overcome the limitation of working memory. In summary, the cognitive dimensions of limited working memory, unlimited long-term memory, schema construction, and schema automation offer a basic architecture for developing CLT and the following empirical studies.

*Three different kinds of load.* CLT assumes that three different kinds of cognitive load exist when learning takes place: extraneous load, intrinsic load, and germane load. *Extraneous load* is determined by instructional design and is influenced by the manner in
which the material is presented or by the activities required of the learner. Sweller, van Merriënboer and Paas (1998) have suggested that extraneous load can be decreased or eliminated by adopting suitable instructional designs and considering appropriate instructional methods.

In contrast to extraneous load, *intrinsic load* is determined by the degree of element interactivity, which is the number of elements that should be processed simultaneously (Sweller, 1994). At first, it was not considered to be changed by instructional methods because the load was intrinsic to the material being learned. Later, however, researchers have shown that intrinsic load also can be manipulated by altering the degree of element interactivity (Pollock, Chandler, & Sweller, 2002). However, element interactivity is related to an individual’s mastery level. Van Merriënboer and Sweller (1991) argue that element interactivity “… can be determined only by counting the number of interacting elements that people deal with *at a particular level of expertise*” (p.150). This indicates that element interactivity cannot be measured merely by analyzing task or material. Some materials are not intelligible to some learners because there are many interacting elements in the materials that have to be processed simultaneously and accordingly; that situation creates overburden and causes high intrinsic load to the learners. However, because they are more experienced, some learners consider a large number of interacting elements as only a single element. Level of expertise determines what counts as an element. Therefore, intrinsic load cannot be determined without considering a learner’s level of expertise (Schnotz & Kürschner, 2007).
Finally, *germane cognitive load* refers to the part of a learner’s effort that is devoted to schema construction and schema automation, which are essential to learning. Sweller, van Merriënboer, and Paas (1998) argued that germane load should be increased as high as possible, but the increased germane load should stay within the limits of working memory. In order to do that, it is important to find appropriate instructional methods that can reduce extraneous load; reduced extraneous load enables learners to redirect their attention to cognitive processes that are relevant to schema construction and schema automation. Thus, the goal is to find instructional designs that decreases extraneous load and at the same time, increase a learner’s effort and motivation. Such an increase is considered to enhance germane cognitive load resulting in schema construction and schema automation (Paas, Renkl, & Sweller, 2003).

CLT proposes that the total cognitive load is the sum of the three kinds of cognitive load: extraneous load, intrinsic load, and germane load. This sum should stay within limited working memory capacity because if the sum exceeds working memory’s limited capacity, learning does not take place effectively (Sweller, 2005). If materials to be learned have high element interactivity, this causes high intrinsic load; thus, extraneous load should be reduced by finding more effective instructional designs that allow learners to stay within their working memory capacity. If both intrinsic load and extraneous load are high due to the ineffective instruction design or high element interactivity, the sum of intrinsic and extraneous load will exceed learners’ working memory capacities, so nothing is left for germane load.

In summary, CLT can inform instructional designs leading to better learning outcomes by suggesting ways to overcome working memory limitation, facilitate schema
construction and schema automation, and utilize humans’ unlimited long-term memory capacity. CLT researchers have found a variety of effective instructional designs that enhance learning outcomes by enabling the total cognitive load to stay within the limited capacity of working memory. Those studies will be reviewed in depth below.

**Empirical Findings from Cognitive Load Research**

CLT was developed based on experiments conducted in the late 1970’s and early 1980’s. These studies, which used puzzle problems such as maze-tracing and Tower of Hanoi, revealed that conventional problems focusing on the means-ends process were not effective for learning. The means-ends approach in problem solving only makes individuals try to reduce differences between problem states and goal states and as a consequence, imposes a big burden on working memory (Sweller, 1983). A means-ends instruction method can prevent schema construction, which is the main object of learning. As research on CLT has proceeded, researchers have invested considerable effort in finding instructional designs that can reduce extraneous load resulting from conventional problem solving methods. Instructional designs based upon CLT include goal-free problems, worked examples, completion problems, bimodal presentation, methods of preventing split-attention, and elimination of redundant information. Each of these has been utilized to reduce extraneous load, but later, researchers have become interested in manipulating intrinsic load as well.

*Manipulating extraneous load.* The study by Sweller and Levine (1982) revealed that students showed better learning from goal-free problems than means-ends analysis problems because the former condition did not give an excessive burden on limited working memory. Two groups of students participated in the maze-tracing experiments
and one group were informed about the goal to be attained while the other group received no information about the goal (goal-free condition). The result indicated that the nonspecific goal led to fewer errors and faster learning of the structure of the problem.

Worked examples also seem to help students direct their attention appropriately to problem solving and their appropriate attention, in turn, reduces extraneous load. The method assists learners to focus on the right task aspects and to facilitate schema acquisition (Paas & van Merriënboer, 1994a). Sweller and Cooper (1985) investigated the use of worked examples and found that the instruction with worked examples in algebra was more effective to help students construct a schema for problem solving. Also, the learners who studied worked examples showed better ability to solve new algebra problems, which shows better transfer, than learners who were requested to solve the same problems by themselves (Cooper and Sweller 1987). Another study revealed that process-oriented worked examples (providing expert’s “why” and “how” information) enhance transfer performances especially for the work that needs complex cognitive skills and has several possible solutions (van Gog, Paas, & van Merriënboer, 2004).

Completion problems are another instructional approach that reduces extraneous load. In completion problems, a given state, a goal state and a partial solution are provided, and learners must complete the partial problems. Completion problems are useful especially in domains such as software design and electronic circuit design. Both worked examples and conventional problems are combined in completion problems. On the one hand, like conventional problems, learners have to find the solutions by themselves and in order to do that, they have to study carefully the partial example provided in the completion problem. On the other hand, by providing the partial
examples (van Merriëboer, Kirschner, & Kester, 2003), completion problems reduce extraneous load much like worked examples. Studies have shown the superiority of completion problems over conventional problems (Paas, 1992; van Merriënboer, 1990; van Merriënboer & de Croock, 1992). The superior results from completion problems presumably result because completion problems reduce extraneous load and help learners direct their attention to the construction of schema.

Another way to reduce extraneous load is by adopting two different modes of presentation—such as visual (written) mode and auditory mode (narration)—instead of using only one mode or the other. If information is presented through two different paths, cognitive load problems are reduced because the limitation of working memory capacity can be enlarged by a dual mode of presentation. The study by Kalyuga, Chandler, and Sweller (1999) proved the superiority of auditory and diagram presentation to visual-only presentation. However, another study (Tabbers, Martens, & van Merriënboer, 2004) revealed that a bimodal presentation should be carefully employed to successfully reduce cognitive load. In their study, the advantage of bimodal presentation diminished in learner-paced instruction. Based on that result, the researchers argued that a bimodal presentation is only advantageous in system-paced instruction. Therefore, instructional conditions should be cautiously examined to determine when bimodal presentation can be effectively used.

Extraneous load can be decreased by preventing split-attention as well. The split attention effect occurs when learners’ attention should diverge between more than two sources and integrate them to understand the material (Yeung, Jin, & Sweller, 1998). It has been found to be one of the major problems in some instructional designs causing
interference with effective learning (Chandler & Sweller, 1991, 1992; Sweller & Chandler, 1991, 1994). Chandler and Sweller (1991), for example, showed 28 first-year trade apprentices who participated in their first experiment learned about how to test insulation resistance with one of the two versions of a booklet. In one version, a diagram and text explaining insulation resistance were presented separately while in the other version, text and diagram are integrated. The apprentices who studied with the integrated version earned higher scores in the two written tests (the first week and the twelfth week). The mean test score after 12 weeks training for the separated format group was even below the mean score for the integrated format group in the first test period. The researchers suggested that the separated version made the apprentices switch their attention between the graphic and text frequently in order to integrate the information to be understood. Because attention and mental resources were devoted to a task unrelated to learning, fewer resources were available for essential learning. As a result, cognitive load was increased and learning outcomes deteriorated.

Extraneous load can be curtailed by eliminating redundant information. If individual sources of information are self-contained (such as a diagram that is intelligible by itself), text merely describing information contained in the diagram is redundant. In this situation, redundant text information imposes increased cognitive load. Conversely, eliminating redundant sources of information benefits learning. This redundancy effect has been demonstrated in several studies using diagrams and text in instructional design (e.g., Chandler & Sweller, 1991; Kalyuga, Chandler, & Sweller, 1999).

Some researchers have considered other factors, such as the levels of element interactivity and the levels of expertise when they investigated redundancy effects.
Sweller and Chandler (1994) examined redundancy effects with the different levels of element interactive tasks in their second experiment. They showed that redundancy made the learning outcome worse especially when the task involved high element interactivity (high intrinsic load). Thirty high school students learned how to use a spreadsheet package and solved two different kinds of problems: problems 1 and 2 were judged to be low element interactive tasks and problems 3 and 4 judged to be high element interactive tasks. The students were assigned into the three different groups. The first group learned the package using conventional textual information and computer while the second group used a modified manual that included textual information integrated with diagrams and computer as well. The third group only used the integrated textual information without contacting with the computer. Asking the two groups of student to use a computer to learn the spreadsheet package was considered to be redundant because the manual was self-contained enough.

The results showed that there was no significant difference among the three groups on low element interactive tasks whereas significant difference was observed among the three groups on high element interactive tasks. The group with only the modified manual outperformed the other two groups. The authors suggest that an instructional design becomes more important when one deals with a high element interactive task because the task itself gives a considerable burden to the person and not enough mental resource is left to perform the task. In this case, the redundant activity, using a computer here, imposes an additional burden to the two groups of students and their performances for high element interactive tasks deteriorated.
Some researchers have investigated the relationship between the level of expertise and task redundancy. A learner’s level of expertise is a critical factor in determining what information is relevant or redundant for the learner and what an instructional design is effective or ineffective (Kalyuga et al., 2003). McNamara, Kintsch, Songer, and Kintsch’s (1996) research found that low-knowledge readers benefited from the modified text that consisted of adding materials explicitly identifying the major subtopics as traits of mammals whereas high-knowledge readers benefitted from the original version. This demonstrated that adding the same material can be beneficial for less proficient subjects but redundant for more proficient ones. When new material is employed, instructors need to consider that adding some material can be redundant for high-ability learners and actually cause unnecessary cognitive load.

*Manipulating intrinsic load.* Earlier instructional methods based on CLT only dealt with the ways to reduce extraneous load caused by the way to-be-learned materials are presented. Initially, intrinsic load was considered to be unchangeable, a feature only of the material to be learned. However, some researchers began to probe issues related to intrinsic load from a new perspective—that intrinsic load can also be manipulated.

Pollock, Chandler, and Sweller (2002) attempted to reduce intrinsic load by altering the degree of element interactivity. Element interactivity of complex material was artificially decreased by breaking the material into smaller parts that could be processed independently rather than simultaneously. Their instructional approach builds on the assumption that complex problems can be effectively solved only after students’ appropriate prior knowledge is built. Students in the study first studied the individual information elements needed to understand a concept. Next, they studied all the
information and how the parts interacted. The researchers showed that intricate information is better learned through the method called the *isolated-interacting elements method*.

In another study supporting the idea that intrinsic load can be manipulated, Kester, Kirschner, and van Merriënboer (2006) showed that learning complex materials for problem solving was better accomplished when declarative knowledge and procedural knowledge are presented separately. Learners who encountered a complex material piece by piece (offering declarative and procedural knowledge in a different time) obtained higher transfer-test and lower mental effort scores than learners presented the same material simultaneously.

One recent study utilizing computer simulation about the ideal gas law showed that intrinsic load could be reduced by presenting the content separately on two successive computer screens (Lee, Plass, & Homer, 2006). Students (n=257) from 7th grade classrooms learned about the ideal gas law from a simulation. Some students studied with two separate screens; the relationship between pressure and volume with a constant temperature (Charles’ law) was presented on the first screen and the relationship between temperature and volume with constant pressure (Boyle’s law) displayed on the second screen. Students were allowed to switch between two screens without restrictions. In contrast, for other students, the relationship of temperature, pressure, and volume of gas were exhibited on a single screen. It was considered that information presented on one screen would represent high element interactivity whereas the same information displayed on two separate screens would create low element interactivity. The results showed that the students who studied on two separate screens (information with low
element interactivity) exhibited higher level of comprehension and better performance on the transfer test. This finding was interpreted as indicating that segmenting high element interactive information into two parts and displaying them successively on a different screen can reduce intrinsic cognitive load.

To this point, studies that have devoted attention to find methods to reduce extraneous load and intrinsic load have been reviewed. In some studies, the amount of load imposed by learning materials was measured in several ways to attempt to better understand why new instructional methods were more effective in achieving better learning. In the next section, various ways of measuring cognitive load will be examined.

The Measurement of Cognitive Load

The total amount of cognitive load is defined as the sum of intrinsic, extraneous, and germane load. However, none of the three types of cognitive load are directly measurable. Instead, cognitive load has been assessed by measuring mental load, mental effort, and performance (Paas & van Merriënboer, 1994a). Mental load provides an indication of expected cognitive capacity demands for a specific task through considering the interaction between task and learner characteristics such as level of expertise, age, and spatial ability. Mental effort refers to the cognitive capacity that is actually allocated by a learner to do a task. Performance offers objective data such as the number of correct test items, number of errors, and time invested for the task.

In order to measure cognitive load, three kinds of techniques have been used in cognitive load research: subjective rating scale techniques, physiological techniques, and task-and performance-based techniques. Paas and van Merriënboer (1993) also
introduced the *efficiency approach* that combines both performance scores and mental effort scores.

*Subjective rating scale techniques* have been developed on the assumption that people have an ability to evaluate their effort invested in a task. Most subjective rating techniques reflect the psychologically oriented concept of overall load. Paas (1992) first adopted this technique in his research to measure mental effort expended on understanding basic statistics. Learners were asked to report their invested effort on a 9-grade symmetrical category scale ranging from a very, very low mental effort (1) to a very, very high mental effort (9). Subjective rating scale techniques also have been utilized to measure the difficulty of material being learned (Kalyuga, Chandler, & Sweller, 1999). It has been demonstrated that subjective rating scale techniques are sensitive to very small differences in cognitive load and are both valid and reliable (Brünken, Plass, & Leutner, 2003; Paas, Tuovinen, Tabbers, & van Gerven, 2003).

*Physiological techniques* have been used to measure cognitive load based upon the assumption that physiological changes can reflect changes in cognitive functioning. These techniques include measures of eye movement, heart activity, and brain activity. For example, heart-rate variability was measured to assess cognitive load in Paas and van Merriënboer’s study (1994b). However, they found that this measure was invalid and insensitive to small changes in cognitive load.

*Task- and performance-based techniques* measure two different task results, on a primary task and on a secondary task. Primary task measures are based on the task performance that is the focus of researchers’ studies, whereas secondary task measures are based on a task performed simultaneously with the primary task, such as measuring
reaction time for detecting visual or auditory signals. The reaction time on the secondary task was a reliable measure in the study by Brünken, Plass, and Leutner (2004). The reaction time of the secondary task in audiovisual primary task was significantly faster than that in the visual-only primary task. This result was consistent with previous studies of modality effect and showed that the secondary task was a reliable measurement. However, the biggest shortcoming of the technique is that the secondary task may affect the outcome of the primary task (Brünken, Plass, & Leutner, 2003).

Based on the conversion of raw mental effort scores and raw performance scores to z scores, the efficiency approach was introduced by Paas and van Merriënboer (1993). If high task performance is combined with low effort, the result is called high-instructional efficiency whereas if low task performance is associated with high effort, the result is called low-instructional efficiency. It was concluded that combinations of task performance and mental effort scores can be more sensitive measures on cognitive costs of training program or learning environments than a task performance score or a mental effort score alone (Paas, Tuovinen, Tabbers, & van Gerven, 2003).

In summary, CLT has been developed based upon the assumptions that there is limited working memory and unlimited long-term memory capacity in human cognition, that three different kinds of load (extraneous, intrinsic and germane load) exist, and that schema construction and schema automation are the goals of education. Many efforts have been made to find better instructional methods that decrease extraneous load and intrinsic load and at the same time to optimize germane load. Furthermore, various measurements of cognitive load have shown that new instructional designs or methods
based upon CLT can be more effective. As a consequence, learning outcomes have been improved.

The Hypotheses of the Present Study

The research reviewed in this chapter suggests that (1) the context of a story can influence reading comprehension and recall, (2) geographically unfamiliar context can cause difficulties in comprehension and recall due to readers’ having a problem activating schemata and evoking prior knowledge that would allow them to integrate multiple elements of information into a single element, (3) unfamiliar context may cause higher cognitive load due to heavier intrinsic load that results from high-element interactivity between the elements in the content about global warming and the elements in unfamiliar geographical background, and (4) signaling can be a good way to reduce cognitive load, and enhance reading comprehension and recall. Studies of signaling have shown that it can effectively direct readers’ attention, and improve recall and understanding. Thus, providing signaling devices such as a title, headings, previews, logical connectives, and typographical cues is likely to significantly enhance comprehension and recall and reduce cognitive load.

Based upon the implications of previous research, four major hypotheses were proposed regarding the effect of context and signaling on comprehension, recall and cognitive load. Hypothesis 1 proposed that there would be differences between groups caused by context familiarity and presence of signaling in terms of the collection of dependent variables (comprehension, recall, and cognitive load). Whether there were differences in groups in terms of comprehension, recall, and cognitive load caused only
by familiarity of context was tested in Hypothesis 2 and only by presence of signaling in Hypothesis 3. Hypothesis 4 focused on the interaction between familiarity of context and presence of signaling. Specifically, the hypotheses for the present study were:

Hypothesis 1: After controlling for students’ prior knowledge about global warming and American and Korean geography, the collection of comprehension, recall and self-reported cognitive load variables will be significantly different among four groups created by variation in familiarity of context and presence or absence of signaling.

Familiarity of context was expected to produce a significant difference among groups in the multivariate set of comprehension, recall and cognitive load measures. Because familiar context should be helpful in activating participants’ schemata and prior knowledge and in turn the activated schemata and prior knowledge should be useful in drawing the essential relations from concepts in text, the students’ reading comprehension and recall in familiar context groups were expected to be enhanced. Also, because working memory load can be greatly decreased when schemata familiar to readers are activated (Bruning, Schraw, & Norby, 2011), students’ cognitive load in familiar context groups is likely to be reduced as well (van Merriënboer & Sweller, 2005).

Similarly, presence or absence of signaling was expected to lead to significant differences among groups in comprehension, recall and cognitive load. Because signaling assists participants in allocating their mental resources to more important content or structure in text (Mautone & Mayer, 2001), cognitive load would be expected to decrease in groups receiving signaling as well as their reading comprehension and recall improved. Together, familiarity of context and presence of signaling together were likely to differentiate groups in the collection of participants’ reading comprehension, recall, and
cognitive load. More specifically, students’ reading comprehension and recall would be enhanced and their cognitive load would be decreased by providing both familiar context and signaling.

Hypothesis 2: Context familiarity will have significant positive effects on comprehension, recall, and self-reported cognitive load.

Familiar context contributes to activating students’ schemata and helps students use their prior knowledge that is relevant to the to-be learned information (McVee, Dunsmore, & Gavelek, 2005). Because appropriate contextual information helps readers to draw the necessary relations among concepts in words and sentences (Schwanenflugel & Shoben, 1983), their reading comprehension and recall benefit from familiar context.

Activated schemata also can free our limited working memory by allowing many elements to be treated as a single element in working memory (Moreno, 2004). In the present study, due to the fact that a geographically familiar (American) context for information about global warming was predicted to be more likely to evoke readers’ schemata, relatively lower cognitive load should be imposed by this familiar context. An unfamiliar context, however, should be less likely to activate relevant student schemata. Thus, the students would be expected to expend more mental resources to understand the passage. Therefore, it was hypothesized that context familiarity would significantly improve comprehension and recall and reduce cognitive load compared to the unfamiliar context.

Hypothesis 3: Signaling will have significant positive effects on comprehension, recall, and self-reported cognitive load.
Signaling is a strategy aimed at guiding the learners’ effective cognitive processing (Mautone & Mayer, 2001). Signaling is assumed to work by helping readers direct their mental resources toward certain aspects of content or structure. As a result, readers attend to more important content and their comprehension and recall of that content will be enhanced. Likewise, signaling is designed to optimize learners’ cognitive load by guiding their attention to significant content and organizational features. According to CLT, effective learning is achieved when cognitive resources are directed to activities that are relevant to learning goals whereas effective learning is hampered when mental resources are directed toward unimportant learning activities (Chandler & Sweller, 1991). Thus, when signaling is provided, readers’ cognitive load should be decreased and recall and comprehension improved.

Hypothesis 4: Signaling will have different effects on comprehension, recall, and self-reported cognitive load depending on context familiarity.

In the present study, students were randomly assigned into four different groups as they read an essay about global warming: 1) a familiar context and signaling group in which they read about global warming in a familiar context and with signaling, 2) a familiar context and no signaling group, 3) an unfamiliar context and signaling group, and 4) an unfamiliar context and no signaling group. Due to the likelihood that an unfamiliar context would generate more cognitive load, reducing mental load by providing signals was expected to lead to better performance in reading comprehension and recall. Thus, signals were expected to enhance comprehension and recall and reduce cognitive load more effectively for students who read information in a geographically unfamiliar context than for students who read it in a familiar one.
Chapter III

Methods

This chapter describes the methods employed to examine the effects of context and signaling on comprehension and recall of passage information and on cognitive load. The current study examined three aspects. The first was whether two different background contexts for the participants (an American context that was familiar to the U.S. students who participated in the study, contrasted with a less-familiar or unfamiliar Korean context) would have significantly different effects on comprehension of global warming related information and on cognitive load. The second was whether signaling had significant effects on students’ comprehension, recall, and self-reported cognitive load variables. The third was whether the combination of these two conditions would produce an interaction in which signaling had greater effects for students who read about information embedded in unfamiliar contexts than for those who read information situated in familiar ones.

In the following sections, participants, experimental materials, experimental procedures are presented and methods of analysis are discussed.

Data Collection

All the data for the current study were collected online. This current study was conducted at a large mid-western university through an online survey website. Participants were 147 students who were enrolled in two intermediate-level undergraduate educational psychology courses in the fall of 2010 semester. Students were randomly assigned to one of four conditions and a hyperlink directing the students to each condition was sent to them.
Students were first requested to provide their demographical information and their levels of confidence in prior knowledge about global warming and about American and Korean geography. Next, they encountered information about global warming phenomena in one of two different contexts and in one of two different signaling conditions (an American signaled version, an American nonsignaled version, a Korean signaled version, and a Korean nonsignaled version). After students read the information about global warming, they took comprehension and recall tests and reported their perceived levels of motivation, difficulty, and mental effort in the same online environment. The characteristics of participants and experimental materials are addressed in the following sections more in detail.

Participants

Students from two undergraduate educational psychology courses were invited to participate in this study. The students in these courses generally were required to participate in 3 hours of research-related activities as part of their course enrollment. The participants consisted of 94 females (63.9%) and 53 males (36.1%) students; most were juniors (37.4%) or seniors (53.7%), with the rest being sophomore (7.5%) or graduate students (1.4%). The participants were majoring in elementary education (27.2%), secondary education (55.8%) or a related field (17%). Most of them were between age 20 to 23 (87.8%) with an overall age range from 19 to 43.

Experimental Materials

Experimental materials for this study were organized into four different components: (1) a preexperimental questionnaire including demographic questions, prior knowledge questions which consisted of one 5-point Likert-type scale about general
global warming knowledge and fourteen questions of students’ confidence in prior
knowledge about global warming facts and about American and Korean geography, (2)
four different versions of reading materials on the topic of global warming, (3) cognitive
load variables, which were self-reported motivation, difficulty and mental effort, and (4)
a post-reading test containing fact questions, inference-making questions, one recall
question.

Preexperimental questionnaire. The preexperimental questionnaire included
requests for demographic information, one self-rating item of students’ prior knowledge
about global warming, and students’ confidence in prior knowledge about global
warming knowledge and about American and Korean geography. The students were
asked to answer demographic questions that assessed their general characteristics and
background information such as age, gender, major and year in school (See Appendix A).
Students were also requested to fill out one self-rating item about global warming that
provided overall students’ levels of prior knowledge about global warming. In addition,
to determine students’ levels of prior knowledge about global warming and about
American and Korean geography more in detail, self-efficacy scales were adopted based
upon Bandura’s guide (Bandura, 2006). Six items about global warming (See Appendix
B) and eight items about American and Korean geography (See Appendix C) were
constructed in self-efficacy scales. Students’ levels of efficacy about global warming
were measured to estimate their levels of prior knowledge. Students’ levels of efficacy
about American and Korean geography were also gauged to obtain their actual
familiarity-nonfamiliarity with American and Korean geography. A level of prior
knowledge about global warming and American and Korean geography for an individual
student was determined by adding up the scores on those items (Koning, Tabbers, Rikers, & Paas, 2007; Mayer & Moreno, 1998).

*Four versions of the reading materials.* Four different versions of passages about global warming were created for this study. The four versions varied in their levels of familiarity of context and in the presence or absence of signaling. Figure 1 provides an illustration of the four different versions of the passages (See Appendix D for the passages themselves).

Figure 1
Four Versions of Reading Materials

Two different contexts were employed as a setting for an explanation of nature of global warming and factors affecting it. The context for information in one text was U.S. environments, while that of the other text was Korean environments. The general global warming facts to be acquired by readers were exactly same in the two texts, but the examples of global warming in two countries were embedded in two different contexts,
U.S. and Korean. In each condition, all illustrations were based upon real cases and valid information, but name of cities or states/provinces, and the name of measures, such as Fahrenheit and Celsius, were different. Table 1 provides an illustration of a global warming–related phenomenon, extreme heat waves, as it occurred in the United States. In the contrasting experimental conditions, the example was presented as having occurred in Korea.

Table 1
A Shared General Fact and Example Cases in Two Different Contexts

<table>
<thead>
<tr>
<th>Shared General Fact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change can directly affect human health by increasing the number of extreme heat waves. According to a study conducted by a research center at University of Chicago, increases in temperature may lead to more extreme heat waves during summer. Heat waves are rare events that vary in character and impact, but they could become more frequent, intense, and long-lasting with global warming.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The U.S. Context</th>
<th>Korean Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the 1990s, Chicago experienced several severe heat waves. In July 1995, a heat wave resulted in 485 heat-related deaths and 739 excess deaths when the temperature was over 98 ºF for 4 days. After consecutive heat events, Chicago implemented a Heat Health Watch/Warning System. The warning system was implemented in other US cities such as Cincinnati, New Orleans, and St. Louis.</td>
<td>During the 1990s, Seoul experienced several severe heat waves. In July 1994, a heat wave resulted in 254 heat-related deaths and 532 excess deaths when the temperature was over 38 ºC for 14 days. After consecutive heat events, Seoul implemented a Heat Health Watch/Warning System. The warning system was implemented in other Korean cities such as Busan, Chunan, and Gwanju.</td>
</tr>
</tbody>
</table>

Each context was then presented in one of two versions; one of them employed signaling devices whereas the other did not. As described earlier, signaling refers to the addition of devices for emphasizing particular semantic content, structures, and organization of the passage, but not for changing meaning or for offering novel information (Loman & Meyer, 1983; Mautone & Mayer, 2001). In the present study, a set
of signaling devices, which included a title, headings, a preview, a summary statement, logical connectives and typographical cues (bold face), were used. Table 2 shows examples of the signaling devices for the present study. A title and headings were used to guide the readers to the most relevant information in the text while a preview and summary statement were adopted to offer overall content before and after the actual content. Logical connectives, such as for example, therefore, also, and likewise, were employed to make the relationship between ideas clear. Typographical cues (boldface) also were utilized to draw the readers’ attention to certain facts.
### Table 2
Examples of Signaling Devices for the Current Study

<table>
<thead>
<tr>
<th>Signaling Devices</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>“Global Warming”</td>
</tr>
<tr>
<td><strong>Headings</strong></td>
<td>‘Increases in precipitation’, ‘Rises in Sea level’</td>
</tr>
<tr>
<td><strong>Preview</strong></td>
<td>Globally, a warmer earth will bring about increases in temperatures, increases in precipitation, increases in the strength of tropical cyclones, and cause rises in sea level. Researchers think that greenhouse gases and greenhouse effect are largely responsible for global warming. Global warming also leads to a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease, and increases in ground-level ozone.</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>In summary, the strong causes of global warming are likely to be greenhouse gases emitted by human activities. Global warming could influence so many areas surrounding human beings such as increases in temperature, precipitation, strength of tropical cyclones, and rises in sea level. Also, it is expected that a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease and ground-level ozone.</td>
</tr>
<tr>
<td><strong>Logical connectives</strong></td>
<td>‘Therefore’, ‘Thus’, ‘Also’, ‘For example’</td>
</tr>
<tr>
<td><strong>Typographical cues</strong> (Boldface)</td>
<td>the Intergovernmental Panel on Climate Change (IPCC) the Massachusetts Institute of Technology</td>
</tr>
</tbody>
</table>

One part from both signaled and nonsignaled global warming passages, sea level rise, in two different contexts is shown in Tables 3 and 4. Because a title, preview and summary statement applied to the whole passage, the tables only show a heading, logical connectives and typographical cues related to the part about sea level rise.
Table 3
Examples of Signaled and Nonsignaled Versions in an American Context

<table>
<thead>
<tr>
<th>Signaling Devices</th>
<th>Signaled Version</th>
<th>Nonsignaled Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heading</td>
<td>Rises in sea level has been also observed in the US, with sea level rising about 0.1 inch per year along most of the US Atlantic and Gulf coasts.</td>
<td>Rises in sea level has been also observed in the US, with sea level rising about 0.1 inch per year along most of the US Atlantic and Gulf coasts.</td>
</tr>
<tr>
<td>Context (American)</td>
<td>Sea level, as estimated by a research team at University of Amsterdam in the Netherlands using tide gauge measurements, has risen approximately 6-8 inches worldwide during the last century. <em>Furthermore</em>, this research team found that the expansion of ocean water, the melting of mountain glaciers and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.</td>
<td>Sea level, as estimated by a research team at University of Amsterdam in the Netherlands using tide gauge measurements, has risen approximately 6-8 inches worldwide during the last century. This research team found that the expansion of ocean water, the melting of mountain glaciers and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.</td>
</tr>
</tbody>
</table>

Each version of reading materials was composed of about 2000 words (American signaled 2027 words, American nonsignaled 1817 words, Korean signaled 2017, and Korean nonsignaled 1801 words). The reading materials were segmented into four parts and after each segment, students were requested to report their levels of eagerness, interest, difficulty and mental effort.
Table 4
Examples of Signaled and Nonsignaled Versions in a Korean Context

<table>
<thead>
<tr>
<th>Signaling Devices</th>
<th>Signaled Version</th>
<th>Non Signaled Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heading</td>
<td>Rises in sea level has been also observed in Korea, with sea level rising about 5.7mm per year, which is much larger than the global rate.</td>
<td>Rises in sea level has been also observed in Korea, with sea level rising about 5.7mm per year, which is much larger than the global rate.</td>
</tr>
<tr>
<td>Context (Korean)</td>
<td>Sea level, as estimated by a research team at University of Amsterdam in the Netherlands using tide gauge measurements, has risen approximately 15-20 centimeters worldwide during the last century. Furthermore, this research team found that the expansion of ocean water, the melting of mountain glaciers, and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.</td>
<td>Sea level, as estimated by a research team at University of Amsterdam in the Netherlands using tide gauge measurements, has risen approximately 15-20 centimeters worldwide during the last century. Furthermore, this research team found that the expansion of ocean water, the melting of mountain glaciers, and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.</td>
</tr>
<tr>
<td>Logical Connective (Furthermore) and Typographical Cues (Boldface)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cognitive load measurements. Subjective rating scale techniques were employed to measure students’ levels of eagerness, interest, difficulty, and the amount of cognitive load imposed on one of four versions of reading materials. Subjective rating scale techniques have been used by many scholars because it has been shown that subjective rating scale techniques are sensitive to very small differences in cognitive load, and the techniques are both valid and reliable (Paas, Tuovinen, Tabbers, & van Gerven, 2003; Brünken, Plass, & Leutner, 2003). After each segment as well as after all four segments, students were asked to report their levels of eagerness, interest, difficulty and mental effort on 5-grade symmetrical category scale ranging from (1) to (5) (See Appendix E). Self-
reported levels of eagerness and interest were measured to provide an indication of how much students were motivated to read each version of the reading materials. Self-reported levels of difficulty were calibrated to estimate how difficult each version of reading material was for students. Self-reported levels of mental effort were appraised to get an idea about how much cognitive load exerted by students when they read one of the four versions of reading material.

*Post-reading test.* Reading questionnaire included thirty multiple-choice comprehension questions and a single recall short-answer question (See Appendix F). The thirty comprehension questions composed of twenty five fact-related comprehension questions and five inference-making questions. Fact-related comprehension questions were constructed to evaluate how well the students learned facts in reading materials and the results were used to calibrate their levels of shallow understanding about the material. Five inference-making questions were constructed to assess their levels of deep understanding. A recall question was particularly made for counting how many names of the universities quoted in the reading material could be remembered by the students.

*Procedures*

Several steps were taken before an experiment was conducted for the current study: (1) e-mail notification that contained a purpose of this study and a hyperlink to an informed consent form was sent to students who were taking two intermediate-level undergraduate educational psychology courses; (2) 161 students granted their informed consent; (3) All 161 students were assigned to one of four conditions using a random number generator; (4) a hyperlink to each condition and a brief explanation about the
study were sent to all 161 students; and (5) finally, 147 students out of 161 participated in this study, reading one of four passages and answering all the questions.

The four passages were an American signaled version, an American nonsignaled version, a Korean signaled version, and a Korean nonsignaled version. Students were first asked to provide demographical information such as age, gender, major and year in school. They were also requested to fill out one self-rating item asking their general levels of prior knowledge about global warming. Additionally, students were asked to offer their levels of confidence about several dimensions of their prior knowledge about global warming and about American and Korean geography. They wrote a number between 1 and 100 that showed their levels of confidence in each item (Bandura, 2006).

After students provided this information, they read one of the four versions of the reading materials. They were instructed by a statement, “This is the first segment of an article on Global Warming. Please read it carefully in preparation for a quiz when you finish reading all four segments.” The reading materials were segmented into four parts. Students were asked to rate their levels of interest, eagerness, difficulty of a reading material, and mental effort using 5-point Likert scale after they read each segment and after all four segments. Next, students were requested to answer 25 fact-related questions, five inference-making questions, and a single recall question. Figure 2 shows all the procedures for the current study.
Figure 2
Experimental Procedure Steps for the Current Study

1. Sending out e-mail notification about a purpose of study and a hyperlink to informed consent
2. Students' granting their informed consent
3. Randomly assigning students to one of four conditions
4. Sending out an email about a hyperlink to one of four experimental conditions
5. Students' providing their demographical information
6. Students' providing information about their levels of prior knowledge
7. Students' reading one of four versions of passages
8. Students' rating levels of interest, eagerness, difficulty and mental effort
9. Students' taking comprehension and recall test
Because the focus of the current study was on whether two different treatments (context and signaling) had significant effects on multiple dependent variables, which were comprehension, recall and cognitive load and because a potential influence of readers’ prior knowledge of global warming phenomena needed to be controlled, a 2X2 multivariate analysis of covariance (MANCOVA) was utilized, in which total scores of students’ levels of confidence in prior knowledge about global warming and about American and Korean geography were used as covariates. After adjusting dependent variables for differences on one or more covariates, a MANCOVA provides an answer to the question of whether there were significant differences among groups (Gardener, 2001).

MANCOVA was considered to be the appropriate method for the present study instead of running several separate ANCOVAs because MANCOVA has several advantages over ANCOVA: (1) it increases the chance of discovering the significant effect of treatments and interaction, (2) it protects against inflated type 1 error due to the multiple tests of dependent variables, and (3) it may show differences not revealed in separate ANCOVAs (Tabachinick & Fidell, 2001).

MANCOVA shows the result for the multivariate analysis first and then univariate analysis next. If the results of the multivariate analysis are significant, it means that the collection of comprehension, recall, and cognitive load is significantly different among the four conditions by the treatments. The result supported Hypothesis 1 for the current study, which was After controlling for students’ prior knowledge about global warming and American and Korean geography, the collection of comprehension, recall
and self-reported cognitive load variables will be significantly different among four
groups created by variation in familiarity of context and presence or absence of signaling.

If context produces a significant effect on the collection of comprehension, recall
and cognitive load, the appropriate next step is to examine the results of univariate
analysis. Theses univariate examinations revealed whether context had a statistically
significant effect on comprehension, recall, or cognitive load individually and provided
answers to the questions posed in Hypothesis 2, which was Context familiarity will have
significant positive effects on comprehension, recall, and self-reported cognitive load.
Likewise, if the multivariate results of signaling effect are significant, the univariate
analysis should be checked as well. It also found whether Hypothesis 3, which was
Signaling will have significant positive effects on comprehension, recall, and self-
reported cognitive load, could be statistically supported.

Hypothesis 4 probed the interactions between the variables, asking whether
Signaling will have different effects on comprehension, recall, and self-reported cognitive
load depending on context familiarity. This hypothesis proposed that signaling was likely
to be more effective in an unfamiliar context—a context that was likely to cause
increasing cognitive load as well as creating problems for schema activation and
utilization of prior knowledge. Hypothesis 4 was tested by individually examining the
interaction between context and signaling on the dependent variables and also together on
those dependent variables.
Chapter IV

Results

In the present study, the effects of background context and signaling on students’ levels of comprehension, recall, and cognitive load were examined. Two different contexts were employed to frame explanations about global warming, which were American geographical background (familiar) and Korean geographical background (unfamiliar). Several types of signaling (e.g., titles, headings, previews, summary statements, logical connectives, and typographical cues) were also adopted for a signaling condition in each context. Context familiarity and presence or absence of signaling served as independent variables for this study. Students’ levels of confidence about global warming and about American and Korean geography were measured to control their potential influences on dependent variables and used as covariates.

Seven dependent variables were originally employed—three learning outcome variables and four cognitive load variables. Learning outcome variables were students’ fact-level learning (Learningfacts), deep understanding (Inference-making), and recall (Recall). Cognitive load variables were students’ self-reported levels of interest (Interest), eagerness (Eager), difficulty (Difficulty), and mental effort (Mentaleffort). Later, only six dependent variables were used because there was a high correlation between two variables (Interest and Eager) and combined them into one variable which was levels of motivation (Motivation).

Students’ fact-level learning (Learningfacts) was measured by 25 fact questions, their levels of deep understanding (Inference-making) were assessed with 5 inference-making questions, and their levels of recall (Recall) were gauged by a single recall
question asking how many names of the universities quoted in the reading material the students remember. Four cognitive load variables, students’ self-reported levels of interest (Interest), eagerness (Eager), difficulty (Difficulty) and mental effort (Mentaleffort) were measured by 5-point subjective rating scales. Results of the study are presented in this chapter. First, research questions and four hypotheses are reviewed. Next, data collected for this study are evaluated based on the assumptions of multivariate analysis of covariance and four research hypotheses are explored. Finally, other interesting findings are reported.

Research Question and Hypotheses

This study was designed to answer questions about the effects of context familiarity (American and Korean) and about the presence or absence of signaling (signaling and nonsignaling) on students’ levels of comprehension, recall and cognitive load. Four hypotheses were made based upon the literature review in the previous chapter:

Hypothesis 1: After controlling for students’ prior knowledge about global warming and American and Korean geography, the collection of comprehension, recall and self-reported cognitive load variables will be significantly different among four groups created by variation in familiarity of context and presence or absence of signaling.

Hypothesis 2: Context familiarity will have significant positive effects on comprehension, recall, and self-reported cognitive load.

Hypothesis 3: Signaling will have significant positive effects on comprehension, recall, and self-reported cognitive load.
Hypothesis 4: Signaling will have different effects on comprehension, recall, and self-reported cognitive load depending on context familiarity.

To examine the four hypotheses, a MANCOVA (multivariate analysis of covariance) was conducted using the SPSS statistical software version 17.0.

Data Evaluation

MANCOVA provides information about whether statistically reliable mean differences between groups exist after adjusting dependent variables for differences on covariates (Tabachnick & Fidell, 2001). To achieve the best results, covariates and dependent variables were evaluated and unequal sample sizes, missing data, normality, and homogeneity of variance-covariance were examined.

Evaluation of Dependent Variables’ Multicollinearity and Singularity

MANCOVA works best when the dependent variables are only moderately correlated. According to Tabachnick and Fidell (2001), if there are two variables with a correlation above 0.70, one of the strongly correlated pairs needs to be removed or the pair combined to form a single measure. Originally, total seven dependent variables were employed to measure students’ comprehension, recall and cognitive load. The correlations among seven dependent variables in the present study were initially examined (see Table 5).

The seven dependent variables were three learning outcome variables, which were fact-level learning of reading materials (Learningfacts), levels of deep understanding (Inference-making), levels of recall (Recall), and four cognitive load variables, which were students’ self-reported levels of interest (Interest), eagerness (Eager), difficulty (Difficulty), and mental effort (Mental effort). Because the correlation between Interest
and Eager was high (0.86), two dependent variables were combined into a single variable and rename it Motivation. Finally, six dependent variables (Learningfacts, Inference-Making, Recall, Motivation, Difficulty, and Mental Effort) were adopted for this study.

Table 5
Correlations among the Seven Dependent Variables

<table>
<thead>
<tr>
<th></th>
<th>Fact-Level Learning</th>
<th>Inference-Making</th>
<th>Recall</th>
<th>Interest</th>
<th>Eager</th>
<th>Difficulty</th>
<th>Mental Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact-Level Learning</td>
<td>_</td>
<td>_</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inference-Making</td>
<td>0.51</td>
<td>_</td>
<td>_</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall</td>
<td>0.42</td>
<td>0.28</td>
<td>_</td>
<td>_</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>0.25</td>
<td>0.16</td>
<td>0.12</td>
<td>_</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eager</td>
<td>0.15</td>
<td>0.12</td>
<td>0.05</td>
<td>0.86</td>
<td>_</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty</td>
<td>-0.31</td>
<td>-0.25</td>
<td>-0.17</td>
<td>-0.32</td>
<td>-0.27</td>
<td>_</td>
<td></td>
</tr>
<tr>
<td>Mental Effort</td>
<td>0.11</td>
<td>-0.03</td>
<td>-0.05</td>
<td>0.50</td>
<td>0.60</td>
<td>-0.14</td>
<td>_</td>
</tr>
</tbody>
</table>

Univariate and Multivariate Outliers

Univariate outliers were detected using the criterion of $Z > 3.3$. Three cases in one dependent variable (Recall) were considered as outliers (see Table 6). The original scores were replaced by the score of the next highest plus one.

Table 6
Univariate Outliers

<table>
<thead>
<tr>
<th>Id</th>
<th>Z score</th>
<th>Original Score</th>
<th>New Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>4.06</td>
<td>8</td>
<td>5 (next highest 4+1)</td>
</tr>
<tr>
<td>97</td>
<td>4.06</td>
<td>8</td>
<td>6 (next highest 5 +1)</td>
</tr>
<tr>
<td>135</td>
<td>4.68</td>
<td>9</td>
<td>4 (next highest 3+1)</td>
</tr>
</tbody>
</table>
Multivariate outliers were assessed using the regression program in SPSS. One multivariate outlier (id 135) was found with six dependent variables and a criterion $\alpha = .001$, critical value $\chi^2 = 22.458$, and was deleted (see Table 7).

Table 7
Mahalanobis Distance Values for Multivariate Outliers with SPSS Syntax

```
REGRESSION
/MISSING LISTWISE
/STATISTICS COEFF OUTS R ANOVA COLLIN TOL
/Criteria=PIN(.05) POUT(.10)
/NOORIGIN
/DEPENDENT ID
/METHOD=ENTER AVEMOT1TOALL AVEDIF1TOALL AVEEFF1TOALL TOTALCOM TOTALINFER TOTALRECALL
/SAVE MAHAL
/RESIDUALS=OUTLIERS (MAHAL).
```

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahal. Distance</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>135</td>
</tr>
<tr>
<td>2</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>134</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>145</td>
</tr>
<tr>
<td>7</td>
<td>82</td>
</tr>
<tr>
<td>8</td>
<td>64</td>
</tr>
<tr>
<td>9</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>34</td>
</tr>
</tbody>
</table>

Unequal Sample Sizes and Missing Data

Initially, 147 students participated in this study but data for 146 students remained after one case was deleted due to its multivariate outlier characteristic. The sample sizes in the four groups varied by a small amount: There were 37 cases in the American signaled condition, 34 in the American nonsignaled condition, 38 in the Korean signaled
condition, and 37 in the Korean nonsignaled condition. Because the MANCOVA analysis in SPSS now offers adjustment for unequal sample sizes (METHOD = UNIQUE), they are no longer problematic. No missing data were found in the four groups.

*Univariate and Multivariate Normality*

Univariate normality was examined by review of the data’s histogram, skewness and kurtosis; none of these methods revealed any serious problem in the data. Because each univariate variable did not seem to violate normality assumptions and because there were far more cases than dependent variables in the smallest cell, it was assumed that multivariate normality was also satisfied (Tabachnick & Fidell, 2001).

*Homogeneity of Variance-Covariance*

Homogeneity of variance-covariance was examined by Box’s M test at the multivariate level and by Levene’s test at the univariate level. In multivariate designs, homogeneity of variances are assumed, which means that dependent variables have equal levels of variance/covariance across the range of independent variable (Green & Salkind, 2005). Table 8 indicates that Box’s M was equal to 82.59, which confirms homogeneity of variance-covariance matrices (F(63, 46642) = 0.12, p>0.05).

<table>
<thead>
<tr>
<th>Table 8</th>
<th>Result of Box’s M test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box’s M</td>
<td>82.59</td>
</tr>
<tr>
<td>F</td>
<td>1.21</td>
</tr>
<tr>
<td>df1</td>
<td>63</td>
</tr>
<tr>
<td>df2</td>
<td>46642.18</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Levene's test indicates whether the assumption of homogeneity of variance for each of the dependent variables is satisfied (Gardner, 2001). Table 9 shows that there was no statistically significant violation for the dependent variables except the Difficulty variable (F(3,142) = 3.69, p<0.05). Tabachnick and Fidell (2001) suggest a more conservative critical alpha level such as .025 or .01 rather than the conventional .05 level should be used for determining significance if homogeneity of error variances is violated for a variable in the univariate F-test. Thus, alpha level .025 for the Difficulty variable was used to determine the significance in the univariate F-test.

Table 9
Result of Levene’s Test

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact-Level Learning</td>
<td>0.28</td>
<td>3</td>
<td>142</td>
<td>0.84</td>
</tr>
<tr>
<td>Inference-Making</td>
<td>0.85</td>
<td>3</td>
<td>142</td>
<td>0.47</td>
</tr>
<tr>
<td>Recall</td>
<td>1.51</td>
<td>3</td>
<td>142</td>
<td>0.22</td>
</tr>
<tr>
<td>Motivation</td>
<td>0.25</td>
<td>3</td>
<td>142</td>
<td>0.86</td>
</tr>
<tr>
<td>Difficulty</td>
<td>3.69</td>
<td>3</td>
<td>142</td>
<td>0.01</td>
</tr>
<tr>
<td>Mental Effort</td>
<td>0.57</td>
<td>3</td>
<td>142</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Assessing Covariates

Homogeneity of regression. For multivariate analysis of covariance, an overall test of homogeneity of regression is required. That is because MANCOVA assumes that the regression between covariates and dependent variables in one group is the same as the regression in other groups. Only when this assumption is satisfied, using the average regression to adjust covariates is reasonable (Tabachnick & Fidell, 2001). This assumption was evaluated by SPSS and showed no violation of this assumption. Table 10 provides the SPSS syntax that was utilized for evaluating homogeneity of regression.
Table 10
SPSS Syntax Utilized to Assess Homogeneity of Regression

MANOVA avemot1toall, avedif1toall, aveeff1toall, totalcom, totalinfer, totalrecall, confgwprrwall, confgeus, confgek BY groupcon, groupsig (1,2)
/PRINT=SIGNIF(BRIEF)
/ANALYSIS = avemot1toall, avedif1toall, aveeff1toall, totalcom, totalinfer, totalrecall
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = avemot1toall
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = avedif1toall
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = aveeff1toall
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = totalcom
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = totalinfer
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig
/ANALYSIS = totalrecall
/DESIGN = confgwprrwall, confgeus, confgek, groupcon, groupsig, groupcon BY groupsig, POOL(confgwprrwall, confgeus, confgek) BY groupcon + POOL(confgwprrwall, confgeus, confgek) BY groupsig + POOL(confgwprrwall, confgeus, confgek) BY groupcon BY groupsig.

Reducing dimensions for covariates. This study employed 15 questions that gauged students’ levels of prior knowledge and the scores were used as covariates. To
perform dimension reduction for the 15 items, one of factor analysis methods—principal component analysis with rotation method (Varimax with Kaiser normalization)—was conducted. Results are shown in Table 11. Three distinct factors were extracted using Kaiser’s criterion, which indicates that only factors with eigenvalues greater than 1 should be retained (Kaiser, 1960). The first factor included items 1 through 8 measuring levels of confidence in prior knowledge about global warming, the second factor consisted of four items determining levels of confidence in prior knowledge about American geography, and the third factor contained four items assessing levels of confidence in prior knowledge about Korean geography. The average scores from each factor were employed as the covariates for this study. Those were students’ levels of confidence in their prior knowledge about global warming, American geography, and Korean geography.
Evaluating covariates. To adjust dependent variables effectively, covariates should be significantly related to them (Pedhazur & Schmelkin, 1991). The relationship between six dependent variables and three covariates were examined by dependent variable (DV)-covariate multiple regressions. All covariates were significantly related to at least one of the DVs, so all of them were remained and used as covariates.

Data Analyses

After the data were examined based on the assumptions of multivariate analysis of covariance and evaluating dependent variables and covariates, a MANCOVA was conducted to find out whether the four hypotheses were supported. Alpha was set at 0.05
for all statistical tests except levels of perceived difficulty (Difficulty, $\alpha = 0.025$). Mean differences on six dependent variables for four groups are displayed first in Table 12 to help understanding of the analyses. Those were three learning outcome variables which were fact-level learning, inference-making and recall, and three self-reported cognitive load variables which were motivation, difficulty, and mental effort.

Table 12
Mean and Standard Deviations on Six Dependent Variables for Four Groups

<table>
<thead>
<tr>
<th>Type of Measure</th>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fact-Level Learning</td>
<td>Inference-Making</td>
<td>Recall</td>
<td>Motivation</td>
<td>Difficulty</td>
<td>Mental Effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS</td>
<td>37</td>
<td>18.05</td>
<td>3.29</td>
<td>3.00</td>
<td>1.37</td>
<td>1.32</td>
<td>1.53</td>
<td>3.10</td>
<td>0.89</td>
<td>2.15</td>
<td>0.81</td>
<td>2.98</td>
</tr>
<tr>
<td>ANS</td>
<td>34</td>
<td>17.94</td>
<td>3.97</td>
<td>3.38</td>
<td>1.23</td>
<td>1.29</td>
<td>1.31</td>
<td>3.06</td>
<td>0.76</td>
<td>2.18</td>
<td>0.61</td>
<td>2.74</td>
</tr>
<tr>
<td>KS</td>
<td>38</td>
<td>18.03</td>
<td>3.90</td>
<td>2.79</td>
<td>1.32</td>
<td>1.82</td>
<td>1.52</td>
<td>2.98</td>
<td>0.92</td>
<td>2.48</td>
<td>0.95</td>
<td>2.97</td>
</tr>
<tr>
<td>KNS</td>
<td>37</td>
<td>16.92</td>
<td>3.90</td>
<td>3.00</td>
<td>1.27</td>
<td>1.22</td>
<td>0.92</td>
<td>2.78</td>
<td>0.95</td>
<td>2.60</td>
<td>0.83</td>
<td>2.81</td>
</tr>
</tbody>
</table>

AS (American Signaled), ANS (American Nonsignaled), KS (Korean Signaled), and KNS (Korean Nonsignaled)

Analyses of Research Hypotheses

*Hypothesis 1: After controlling for students’ prior knowledge about global warming and American and Korean geography, the collection of comprehension, recall and self-reported cognitive load variables will be significantly different among four groups created by variation in familiarity of context and presence or absence of signaling.*

To examine Hypothesis 1, comparisons were made between groups with a multiple analysis of covariance (MANCOVA) using four groups (AS, ANS, KS, and KNS) as between-subject factors and the scores of students’ fact-level learning, inference-making, recall, and their self-reported levels of their motivation, difficulty and mental effort as dependent variables. The MANCOVA revealed a significant treatment
effect, Wilks’ λ=0.79 F(3,142) = 1.83, P<0.05, partial η² = 0.08. Partial η² is generally utilized to determine practical importance for MANCOVA. Cohen (1992) suggested criteria for partial η². According to him, partial η² .02 is small, 0.15 is medium and 0.35 is large.

Univariate analysis revealed that groups were significantly different in their levels of inference-making ability (F(3,142) = 3.21, P<0.05, partial η² = 0.07) and perceived levels of difficulty (F(3,142) = 3.43, P<0.025, partial η² = 0.07). Results are presented in Table 13.

Table 13
Univariate Analysis by Group

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP</td>
<td>Fact-Level Learning</td>
<td>3</td>
<td>13.19</td>
<td>1.00</td>
<td>0.40</td>
<td>0.02</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Inference-Making</td>
<td>3</td>
<td>4.60</td>
<td>3.21</td>
<td>0.03</td>
<td>0.07</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>Recall</td>
<td>3</td>
<td>1.83</td>
<td>1.11</td>
<td>0.35</td>
<td>0.02</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>3</td>
<td>1.28</td>
<td>1.82</td>
<td>0.15</td>
<td>0.04</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>3</td>
<td>2.23</td>
<td>3.43</td>
<td>0.019</td>
<td>0.07</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Mental Effort</td>
<td>3</td>
<td>0.56</td>
<td>0.99</td>
<td>0.40</td>
<td>0.02</td>
<td>0.27</td>
</tr>
</tbody>
</table>

As can be seen in Figure 3, students who read the nonsignaled American passage showed the highest inference-making performance (M = 3.38) and students who read the nonsignaled Korean and the signaled American passages show the second highest (M = 3.00). Students who read the signaled Korean passage displayed the lowest inference-making performance (M = 2.79).
Figure 3
Self-Reported Level of Inference-Making in Four Groups

Figure 4 shows that students who read the nonsignaled Korean passage reported the highest perceived level of difficulty ($M = 2.60$) whereas students who read the signaled American passage reported the lowest perceived level of difficulty ($M = 2.15$). Students who read the signaled Korean and the nonsignaled American passages documented the second highest ($M = 2.48$) and the third highest perceived level of difficulty ($M = 2.18$) respectively.
Hypothesis 2: Context familiarity will have significant positive effect on comprehension, recall and self-reported cognitive load.

The second hypothesis was examined by the main effect of context. Context and signaling as between-subject factors and the same DVs were used for the comparisons between groups with a multiple analysis of covariance (MANCOVA). The MANCOVA revealed a significant context main effect, Wilks’ $\lambda=0.87$ $F(1,142) = 3.25$, $P<0.05$, partial $\eta^2 =0.13$.

As can be seen in Table 15, univariate analysis revealed that context had a significant effect on inference-making ($F(1,142) = 4.73$, $P<0.05$, partial $\eta^2 = 0.03$), self-reported levels of motivation ($F(1,142) = 3.11$, $P<0.05$, partial $\eta^2 = 0.03$), and perceived levels of difficulty ($F(1,142) = 6.50$, $P<0.025$, partial $\eta^2 = 0.07$).
Table 14
Univariate Analysis by Context

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTEXT</td>
<td>Fact-Level Learning</td>
<td>1</td>
<td>22.95</td>
<td>1.73</td>
<td>0.19</td>
<td>0.01</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Inference-Making</td>
<td>1</td>
<td>6.75</td>
<td>4.73</td>
<td>0.03</td>
<td>0.03</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Recall</td>
<td>1</td>
<td>0.53</td>
<td>0.32</td>
<td>0.57</td>
<td>0.00</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>1</td>
<td>3.11</td>
<td>4.42</td>
<td>0.04</td>
<td>0.03</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>1</td>
<td>6.50</td>
<td>9.99</td>
<td>0.00</td>
<td>0.07</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>Mental Effort</td>
<td>1</td>
<td>0.02</td>
<td>0.03</td>
<td>0.86</td>
<td>0.00</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Mean differences on fact-level learning, inference-making, recall, motivation, difficulty, and mental effort for context are shown below in Table 15. This shows that American context had positive effects on inference-making (American M = 3.18 and Korean M = 2.89), self-reported motivation (American M = 3.08 and Korean M = 2.88), and perceived difficulty (American M = 2.17 and Korean M = 2.54).

Table 15
Mean and Standard Deviations on Six Dependent Variables between Two Contexts

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>71</td>
<td>18.00</td>
<td>3.61</td>
<td>3.18</td>
<td>1.31</td>
<td>1.31</td>
<td>1.42</td>
<td>3.08</td>
<td>0.82</td>
<td>2.17</td>
<td>0.72</td>
<td>2.86</td>
<td>0.68</td>
</tr>
<tr>
<td>Korean</td>
<td>75</td>
<td>17.48</td>
<td>3.91</td>
<td>2.89</td>
<td>1.29</td>
<td>1.52</td>
<td>1.29</td>
<td>2.88</td>
<td>0.93</td>
<td>2.54</td>
<td>0.89</td>
<td>2.89</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Hypothesis 3: Signaling will have significant positive effect on comprehension, recall and cognitive load.

The MANCOVA revealed that signaling did not have a significant effect on DVs, Wilks’ $\lambda=0.92$ F(1,142) = 0.08, P>0.05, partial $\eta^2$ =0.08. Because the multivariate analysis showed an unexpected result, univariate analyses were also examined even though the multivariate effect was not significant. Univariate analysis showed that signaling had a significant effect on inference-making ability (See Table 16).

Table 16
Univariate Analysis by Signaling

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Observed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNALING</td>
<td>Fact-Level Learning</td>
<td>1</td>
<td>3.46</td>
<td>0.26</td>
<td>0.61</td>
<td>0.00</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Inference-Making</td>
<td>1</td>
<td>6.83</td>
<td>4.78</td>
<td><strong>0.03</strong></td>
<td>0.03</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Recall</td>
<td>1</td>
<td>2.18</td>
<td>1.33</td>
<td>0.25</td>
<td>0.01</td>
<td>.209</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>1</td>
<td>0.53</td>
<td>0.76</td>
<td>0.39</td>
<td>0.01</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>1</td>
<td>0.12</td>
<td>0.18</td>
<td>0.67</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Mental Effort</td>
<td>1</td>
<td>1.61</td>
<td>2.82</td>
<td>0.10</td>
<td>0.02</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Mean of inference-making between signaling and nonsignaling groups in Table 17 shows that signaling had a negative effect on inference making (Signaled M = 2.81, SD = 1.34 and nonsignaled M = 3.18 SD = 1.26).
Table 17
Mean and Standard Deviations for Six Dependent Variables in Signaled and Nonsignaled Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Type of Measure</th>
<th>Fact-Level Learning</th>
<th>Inference-Making</th>
<th>Recall</th>
<th>Motivation</th>
<th>Difficulty</th>
<th>Mental Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Signaled</td>
<td>71</td>
<td>18.04</td>
<td>3.59</td>
<td>2.89</td>
<td>1.34</td>
<td>1.57</td>
<td>1.53</td>
</tr>
<tr>
<td>Nonsignaled</td>
<td>75</td>
<td>17.41</td>
<td>3.94</td>
<td>3.18</td>
<td>1.26</td>
<td>1.25</td>
<td>1.12</td>
</tr>
</tbody>
</table>

*Hypothesis 4: Signaling will have different effects on comprehension, recall and cognitive load depending on context familiarity.*

The MANCOVA revealed no significant interaction between context and signaling, Wilks’ $\lambda=0.98$, $F(1,142)=0.42$, $P>0.05$, partial $\eta^2=0.02$, nor were there any significant univariate interaction on the dependent variables. Therefore, Hypothesis 4 was not supported by the statistical findings.

*Summary of Results*

The first hypothesis was supported by the data. The four groups distinguished by context and signaling were significantly different in the composition of dependent variables (Fact-level learning, inference making, recall, motivation, difficulty, and mental effort) after controlling covariates (the levels of students’ confidence in prior knowledge about global warming, and about American and Korean Geography). Follow-up univariate analyses revealed that the four groups were significantly different in the levels of inference-making and perceived difficulty of the passages. The second hypothesis was also supported. The performance of students who read the American context global warming passage was significantly different from that of students who read the Korean context passage on the combination of dependent variables. Specifically, univariate
analyses showed differences favoring the American context groups in their levels of inference-making, self-reported motivation, and perceived difficulty of the passages. The third and fourth hypotheses were not supported by results of the MANCOVA analysis. Even though the presence of signaling did not significantly differentiate groups in the composite set of dependent variables, the univariate analyses showed that students who read the nonsignaled version performed significantly better in inference-making than students who read the signaled version. In contrast to the expectation that signaling would have more effect on unfamiliar Korean context in the composition of dependent variables, no significant interaction between context and signaling was found.

Other Research Findings

Prior knowledge about American and Korean geography. Potential differences between the participants’ levels of confidence in American and Korean geography were investigated by an analysis of variance (ANOVA). A one way ANOVA revealed that there was a significant difference between the level of confidence about prior knowledge of American (M = 94.76, SD = 14.23) and Korean (M = 41.16, SD = 26.61) geography (F(1, 142) = 460.44, P < 0.01, partial η² = 0.61). As expected, participants in the current study—who all were American students—were more confident in the levels of prior knowledge about American geography than Korean geography.

The effect of segments. The passages about global warming were segmented into four parts and the possibility of changes across the four segments in students’ reported levels of motivation, judged difficulty and mental effort were examined by an analysis of variance (ANOVA). A one way ANOVA also revealed segments had a significant effect on motivation (F (3, 142) = 4.47, P < 0.05).
The mean plots for each of the four groups that are presented in Figure 5 show that the patterns among four segments were similar across the four groups in terms of their respective assessments of their motivation and mental effort. Students showed moderate levels of motivation on the first segment and they showed the least motivation on the second segment. On the third segment, their levels of motivation increased, but then were reduced again on the final segment. These patterns were same in self-reported mental effort. Students invested the highest self-reported mental effort on the third segment in which they exhibited the highest self-reported motivation whereas they reported the least mental effort on the second segment in which they showed the least motivation.

Figure 5
The Change of Patterns across the Four Segments in Motivation and Mental Effort

*The predictors of mental effort.* Students were asked to report the amount of mental effort as a measure of cognitive load. Because students’ perceived level of mental effort was not attributed to the independent variables in the current study, context familiarity and presence or absence of signaling, multiple regression was conducted in
order to probe significant factors that might explain the variability in mental effort. The predictors were the levels of confidence in prior knowledge about global warming, the levels of confidence about American geography and Korean geography, and the levels of reported motivation and difficulty. Regression analyses were performed within SPSS.

The linear combination of predictors was significantly related to the level of mental effort, \( F(5, 145) = 15.76, p<0.001 \). The sample multiple correlation coefficient was 0.60 indicating that approximately 36% of the variance of mental effort could be accounted for by the linear combination of the predictors. Table 18 shows that only two of the independent variables (the level of confidence in prior knowledge about global warming and the level of self-reported motivation) contribute significantly to prediction of levels of self-reported mental effort.

Table 18
Relationships between the Five Independent Variables and Self-Reported Mental Effort

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>1.09</td>
<td>0.45</td>
<td>2.40</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Levels of prior knowledge about global warming</td>
<td>-0.01</td>
<td>0.00</td>
<td>-0.24</td>
<td>-2.73</td>
<td>0.01</td>
</tr>
<tr>
<td>Levels of confidence about US geography</td>
<td>0.01</td>
<td>0.00</td>
<td>0.09</td>
<td>1.18</td>
<td>0.24</td>
</tr>
<tr>
<td>Levels of confidence about Korean geography</td>
<td>0.00</td>
<td>0.00</td>
<td>0.09</td>
<td>1.10</td>
<td>0.27</td>
</tr>
<tr>
<td>Levels of motivation</td>
<td>0.54</td>
<td>0.06</td>
<td>0.63</td>
<td>8.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Levels of difficulty</td>
<td>0.03</td>
<td>0.07</td>
<td>0.04</td>
<td>0.53</td>
<td>-0.14</td>
</tr>
</tbody>
</table>

To further examine the current data, the students were divided into two groups by a median score (median = 3.0) of self-reported motivation. Students who reported their
levels of motivation equal to or higher than the median 3.0 constituted a high-motivation group and students who informed their self-reported motivation lower than 3.0 formed a low-motivation group. High- and low-motivation groups then were employed as an independent variable and levels of mental effort as a dependent variable. The result of analysis of variance (ANOVA) revealed that self-reported levels of mental effort were significantly different between the high- (M = 2.60) and low-motivation groups (M = 3.17), F(1, 144) = 24.25, P <0.01, partial η^2 = 0.14.

The effects of levels of confidence in prior knowledge. Possible effects of levels of confidence in prior knowledge about global warming on six dependent variables were examined. That is, whether effects of context or signaling on the dependent variables varied depending on students’ levels of confidence in prior knowledge about global warming were investigated. The students were divided into two groups by the median level (median = 60) of confidence in prior knowledge about global warming. Thus, the high-confidence group included students who had confidence scores equal to or higher than 60 and the low-confidence group consisted of students who reported confidence scores lower than 60.

The effects of levels of confidence in global warming knowledge and context on six dependent variables were examined first. The multivariate analysis of variance (MANOVA) revealed a significant main effect of context (Wilks’ λ=0.90 F(1,142) = 2.61, P<0.05, partial η^2 =0.10), and a significant main effect of levels of confidence in global warming knowledge (Wilks’ λ=0.89 F(1,142) = 2.77, P<0.05, partial η^2 =0.11). No interaction between them was significant in either the univariate or multivariate analysis. Univariate analysis showed that the level of confidence in global warming knowledge
had a significant effect on fact-level learning (F(1,142) = 7.16, P<0.05, partial η² = 0.05), inference-making (F(1,142) = 11.37, P<0.05, partial η² = 0.07) and self-reported motivation (F(1,142) = 4.48, P<0.05, partial η² = 0.03). All of these differences favored the high-confidence group.

The effects of levels of confidence in global warming knowledge and signaling on six dependent variables were also examined. The results of multivariate analysis of variance (MANOVA) showed a significant main effect of levels of confidence in global warming (Wilks’ λ=0.90 F(1,142) = 2.45, P<0.05, partial η² =0.10). The univariate analysis revealed that the interaction between levels of confidence in global warming knowledge and presence or absence of signaling was significant in inference-making (F(1,142) = 4.08, P<0.05, partial η² = 0.03). Table 19 shows mean scores and standard deviations in inference-making between the two groups, and Figure 6 also shows the mean differences between them.

Table 19
Mean Differences in Inference-Making between the High- and Low-Confidence Groups

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High- Confidence Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signaled</td>
<td>3.03</td>
<td>1.31</td>
</tr>
<tr>
<td>Nonsignaled</td>
<td>3.76</td>
<td>1.02</td>
</tr>
<tr>
<td>Low-Confidence Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signaled</td>
<td>2.74</td>
<td>1.38</td>
</tr>
<tr>
<td>Nonsignaled</td>
<td>2.64</td>
<td>1.23</td>
</tr>
</tbody>
</table>
Figure 6
Mean Differences in Inference-Making between High-Confidence and Low-Confidence Groups

Estimated Marginal Means of Inference-Making

GROUPSIG
- Signaled
- Nonsignaled

High and Low Prior Knowledge
Chapter V
Discussion

This study was undertaken based on the writer’s curiosity about how familiar and unfamiliar geographical background context for the same content influences readers’ comprehension, recall and cognitive load, and how presence or absence of signaling for the content affects them. In addition, this study examined the writer’s question about how presence of signaling might modify the effects of familiar or unfamiliar context on comprehension, recall, and cognitive load. Four hypotheses were explored and the results were presented in the previous chapter. In this chapter, the results are discussed and interpreted from the perspectives of schema theory and cognitive load theory (CLT).

In this writer’s judgment, the most important findings addressed in the previous chapter were that: 1) significant differences existed between American students’ levels of confidence in their prior knowledge about American geography and Korean geography; 2) four groups created by variation in familiarity of context and by presence or absence of signaling exhibited significantly different levels of inference-making and perceived levels of difficulty; 3) context familiarity had significant positive effects on the levels of inference-making, the self-reported levels of motivation, and the perceived levels of difficulty; 4) presence of signaling had a negative effect on the levels of inference-making especially for the group having high-confidence in their global warming knowledge (a further examination found that an expertise reversal effect existed in students’ inference-making performances); and 5) students’ levels of mental effort were accounted for by their levels of confidence in prior knowledge about global warming and their self-reported levels of motivation. The pattern of changes in the level of motivation
across four segments and those in the levels of mental effort across the four segments were quite similar. After the discussion of the results, implications and limitations are discussed, and conclusions offered.

Discussion of Results

Significant Differences in Prior Knowledge about American and Korean Geography

In the current study, context was defined by two different geographical backgrounds—American and Korean—that were employed in text materials used to describe global warming. It was assumed that the American context for encountering information about global warming would be more familiar for American students while the Korean context would be less familiar for them. The analysis for the level of self-rated prior knowledge about American and Korean geography showed that the American students were in fact significantly more confident in their knowledge of American geography (M = 94.76) than Korean geography (M = 41.16), F(1, 142) = 460.44, P < 0.01, partial η² = 0.61.

Based on the well-known relationship between self-efficacy and actual performance (e.g., Bandura, 1982; Pajares, & Miller, 1994; Schunk, 1984; Shell, Murphy & Bruning, 1989), participants’ stating their greater confidence in their knowledge of American geography likely indicates that they also would be more familiar and knowledgeable about it. Thus, the finding of large differences here is reasonable evidence for the assumption that participants’ American geographical knowledge was greater on average than their Korean geographical knowledge and that the two conditions would have been likely to be sufficient to create two different contexts for learning about global warming.
Significant Differences among Four Groups in Perceived Level of Difficulty

The analysis for Hypothesis 1 compared four groups (American signaled, American nonsignaled, Korean signaled, and Korean nonsignaled) on the collection of six dependent variables (Learning facts, Inference-making, Recall, Motivation, Difficulty of passages, and Mental effort) after controlling students’ levels of confidence in prior knowledge about global warming and about American and Korean geography. The first hypothesis was supported by the results of a multivariate analysis of covariate (MANCOVA), which showed that the four groups were significantly different on the combination of six variables, Wilks’ $\lambda = 0.79$ $F(3,142) = 1.83$, $P<0.05$, partial $\eta^2 = 0.08$.

Subsequent univariate F-tests used to interpret the MANCOVA result showed that the four experimental groups differed significantly in participants’ judged levels of difficulty and inference-making. The study’s participants, who were American college students thought that the nonsignaled Korean context was the most difficult passage ($M = 2.60$) whereas the signaled American context was the least difficult ($M = 2.15$).

The difference in adjudged difficulty can be explained by schema theory and CLT. From the perspective of schema theory, the Korean geographical background would be less likely to activate American students’ schemata because it was unfamiliar to them. That is, information about the Korean geographical background as well as information relating to global warming phenomenon would need to be simultaneously processed in working memory. In contrast, the American geographical background would not have needed deliberate processing in working memory because the familiar geographical background could be comprehended with little or no effort; automatic schema-driven processing would free working memory capacity (Mayer, 2005; Sweller, 2005; Sweller &
Chandler, 1994). For instance, for those reading the “American” passage, the explanation of global warming employed the names of U.S. cities or states/provinces, and the measurement units being used in the U.S. such as Fahrenheit and miles. When students are accessing familiar information from their long-term memory that is already schematically organized in their schemata, working memory limits are less likely to be reached. In contrast, using similar reasoning, reading materials in a Korean context would require more working memory capacity and also lead to judgments of the participants that the Korean context as being more difficult.

These results also can be interpreted by the perspective of CLT. According to CLT, intrinsic load is the load inherently tied to the material being learned (Chandler & Sweller, 1991). Intrinsic cognitive load depends on the level of element interactivity, which is the number of elements that should be handled concurrently (van Merriënboer & Ayres, 2005). Materials with high intrinsic load are difficult to understand because the number of elements processed simultaneously is large (van Merriënboer & Sweller, 2005). From this perspective, it can be inferred that the Korean context would impose higher intrinsic cognitive load than the American context because students’ reading about global warming in the Korean context had to simultaneously process elements in the unfamiliar geographical background and elements in the content regarding global warming. This situation would be likely to increase element interactivity, generate greater intrinsic load and aggravate perceived level of difficulty.

A similar explanation may be offered for why the students regarded the nonsignaled passages as being more difficult than the signaled passages. In general, signaling helps readers direct their attention to more important information and ignore
irrelevant information (Loman & Mayer, 1983; Mautone & Mayer, 2001). In other words, by minimizing extra processing of unimportant information (Moreno, 2007), signaling reduces element interactivity and in turn, decreases intrinsic load and perceived level of difficulty in text. In the present study, the signaled passages employed a title, headings, a preview, a summary statement, logical connectives, and typographical cues (bold face) for university names. As shown in previous research (e.g., Lorch & Chen, 1986; Lorch & Lorch, 1985; Lorch, Lorch, & Inman, 1993), providing such signaling devices was expected to help the students concentrate on important information and ignore unnecessary information and thus lead to decrease of levels of difficulty in the signaled passages as well as decrease of element interactivity. As a result, the students considered the unsignaled passages as being more difficult than the signaled passages.

**Context Effects on Comprehension and Cognitive load**

The design for analysis of Hypothesis 2 involved utilizing context as an independent variable and six dependent variables within a multiple analysis of covariance (MANCOVA). The second hypothesis was supported by the MANCOVA result revealing a significant context main effect, Wilks’ $\lambda=0.87$ $F(1,142) = 3.25$, $P<0.05$, partial $\eta^2 =0.13$. Subsequent univariate F-tests used to interpret the MANCOVA result showed that the four groups were significantly different in inference-making, self-reported levels of motivation, perceived levels of difficulty.

Students’ levels of understanding were gauged by five inference-making questions, designed to measure deep understanding and twenty-five comprehension questions, designed to measure learning facts and information. Students who read American context passages showed significantly better inference-making about global
warming (inference-making $M = 3.18$) than students who read the Korean context passages (inference-making $M = 2.89$). Effects of context were less clear, however, for the multiple-choice fact-learning questions, which were targeted at fact-level learning. In other words, the students who read information framed in an American context also exhibited the result favoring fact-level learning, but only marginally higher scores ($M = 18.00$) than the students who read information framed in a Korean context ($M = 17.48$).

Students who read the American context passages also reported a higher level of motivation ($M = 3.08$), and reported a lower level of perceived difficulty ($M = 2.17$) than students who read the Korean context passages (motivation $M = 2.88$; difficulty $M = 2.54$, respectively). Results also showed that familiar context exerted a positive effect on deep comprehension, as measured by the inference-making variable. Familiar context also had a positive effect on cognitive load supported by perceptions of a higher level of motivation and a lower level of difficulty.

These findings support the claim that encountering information—in this case, information about global warming—in a familiar context can facilitate students’ deep comprehension and produce higher levels of motivation and lower levels of difficulty. The fact that students’ reading information in a familiar context was beneficial in terms of deeper understanding, higher self-reported levels of motivation, and lower perceived levels of difficulty is explained by the perspective of CLT, specifically by the concepts of germane load and intrinsic load (Sweller, van Merriënboer, & Paas, 1998). Germane load is the portion of load invested in processes directly relevant to learning (Sweller, 2005) and intrinsic load is the portion of load caused by intrinsic characteristics of the task itself and determined by element interactivity (Sweller, van Merriënboer, & Paas, 1998).
Significant differences in students’ self-reported levels of motivation can be interpreted by germane load. Learners need to be motivated in order to invest their mental resources in learning activities for schema activation, construction and automation. Paas, Tuovinen, van Merriënboer and Darabi (2005), for instance, suggest that motivation is a critical factor for engaging learners in relevant learning activities and enhancing their engagement. Paas, Renkl and Sweller (2003) argue that an increase in effort or motivation “...can increase the cognitive resources devoted to a task. If relevant to schema acquisition and automation, such an increase also constitutes an increase in germane cognitive load” (p. 2).

Based upon the reasoning above, the self-reported level of motivation can be regarded as a reasonable proxy for germane cognitive load. If one group of learners were more motivated and obtained higher scores on a test than another group, this could indicate that the former group invested more mental effort in the task relevant to schema construction and automation, and that their self-reported levels of motivation would be measuring levels of germane load invested. However, this reasoning cannot be utilized in a case where learners in one group showed poorer learning outcomes even though they reported being more highly motivated than another group. In such a case, because a higher level of motivation has not led to higher learning outcomes, the levels of motivation cannot be a proxy for gauging levels of germane load. In the current study, however, because students’ levels of deep understanding measured by inference-making questions in a familiar American context condition were in fact higher than those in an unfamiliar Korean condition, the higher levels of perceived motivation reported by the
students in an American context condition can be used as a potential index of the 
germane load allocated to inference-making.

As addressed before, level of perceived difficulty is influenced by intrinsic load 
measured by element interactivity (van Merriënboer & Ayres, 2005). Because the 
American geographical background was familiar for American students, they presumably 
did not need to invest as much of their mental resources to comprehend information in 
the passage. That is, if the background information was processed with little or no effort, 
the number of elements that needed to be processed simultaneously (element interactivity) 
would be small, which would lead to a decrease of intrinsic load and in turn to a decrease 
perceived difficulty. Participants could allocate most of their mental resources to 
understanding the global warming content. In other words, more mental resources would 
be available for deep understanding.

In summary, the result showing positive context effects on inference-making and 
on perceived difficulty and motivation demonstrate that a familiar context for learning 
new information can potentially increase germane load and decrease intrinsic load and, as 
a consequence, produce deeper understanding. In contrast, additional cognitive load 
introduced by presenting important content (e.g., of scientific findings, principles) in an 
unfamiliar context can decrease readers’ motivation, increase the sense of the content’s 
difficulty, and reduce deep understanding of the content by diverting attention away from 
the central tasks of comprehension (Tabbers, Martens, & Van Merriëboer, 2004), and 
increasing extraneous cognitive load.
Negative Signaling Effects on Deep Comprehension

The third hypothesis—that signaling would have significant positive effect on comprehension, recall, and cognitive load—was not supported by the MANCOVA result. Signaling and nonsignaling groups were not significantly different in analysis of the combination of six dependent variables. Even though most subsequent univariate F-tests did not show significant differences between two groups, the results mostly favored the signaling groups, which showed somewhat higher levels of fact-level learning and recall, along with higher self-reported levels of motivation and lower levels of difficulty. Although only one univariate F-test was significant, this finding was an especially interesting one—that signaling had a negative effect on deep comprehension gauged by inference-making questions (signaling M = 2.81, and nonsignaling M = 3.18). This result was unexpected—Hypothesis 3 had predicted that signaling would have a positive effect on inference-making.

A further examination was conducted to find out why signaling might have had this unexpected effect on deep comprehension. One possibility was that inference-making may have been affected by levels of prior knowledge. To examine whether the effect of signaling on deep understanding was different depending on participants’ levels of confidence in their prior knowledge about global warming, students were divided into high and low-confidence group by a median split on their self-reported prior knowledge about global warming. A significant interaction between signaling and low/high-confidence group was detected. Students who had high-confidence in their prior knowledge about global warming and were in the nonsignaled passage condition exhibited better inference-making ability (M = 3.76) than the signaled passage condition.
(M = 3.03). In contrast, students in the low-prior knowledge confidence group showed better inference-making performance in the signaled passage condition (M = 2.74) than in the nonsignaled passage condition (M = 2.64).

As previously stated, students displaying higher confidence in their prior knowledge of global warming was taken in the present study as an indicator of greater actual knowledge about the subject matter content, global warming, based on the well-known relationship between self-efficacy and actual performance (Bandura, 1982). That is, high and low reported confidence about levels of prior knowledge was considered to be an indicator of actual level of expertise. Specifically, students reporting more confidence in their prior knowledge about global warming were judged to be more likely to actually have higher levels of expertise about global warming, while those with lower confidence about their prior knowledge were judged to be more likely to have low levels expertise about global warming. If these assumptions are true, then the expertise reversal effect can be applied to explain the results (Kalyuga, Ayres, Chandler, & Sweller, 2003).

Low prior knowledge learners presumably lack schemata relevant to a task or situation at hand, so instructional guidance can act as a substitute for activating pre-existing schemata relevant to learning (Sweller, 1999). Thus, providing instructional guidance minimizes working memory load as well as enhances their learning. In contrast, high prior knowledge learners bring more pre-existing schemata to the process of comprehending a situation or task, so additional instructional guidance is redundant. It may even be, as in the present instance, that providing instructional guidance can interfere with learning by forcing learners to invest unnecessary mental effort in the additional instructional guidance (Kalyuga, Ayres, Chandler, & Sweller, 2003).
In the present study, signaling devices such as a title, headings, a preview, a summary statement, logical connectives and bold face typographical cues were employed to help students direct their attention to important aspects of the text materials. Providing such signaling devices was effective for enhancing deep understanding necessary to inference-making for the low-prior knowledge group. Students in the high-prior knowledge group, however, may have been unable to avoid attending to the information in the signals even as they did not require signaling devices due to their high levels of prior knowledge. That is, for the high-prior knowledge group, providing signaling devices may have produced extraneous load. As a result, this group’s processes of constructing more sophisticated mental representations for deep understanding may have been hindered, resulting in poor performances in inference-making.

Predictors of Mental Effort

Self-reported levels of mental effort devoted to reading one of the four different kinds of text (American signaled, American nonsignaled, Korean signaled and Korean nonsignaled) were measured by participants’ overall estimates of how much cognitive load was invested to understand each of the four different kinds of text. Unlike the expectations based upon the literature review (Bransford & Johnson, 1972; Kalyuga, & Sweller, 2004; Steffensen, Joag-dev, & Anderson, 1979; Sweller & Chandler, 1994), neither context nor signaling made any difference among the four groups in their self-reported levels of mental effort. In order to find out whether other factors might have affected self-reported levels of mental effort, however, additional exploration of possible factors was undertaken using a multiple regression analysis. Levels of confidence in prior knowledge about global warming, levels of confidence in the US geography, levels of
confidence in Korean geography, self reported levels of motivation and perceived levels of difficulty were entered as predictors of mental effort.

The multiple regression results indicated that the level of mental effort was significantly accounted for by the level of self-reported motivation and level of self-reported prior knowledge variables. There was a substantial positive part correlation (0.57) between the level of mental effort and the level of motivation. The part correlation for the level of mental effort and the level of motivation is the correlation between two variables after partialling out of the level of motivation variability shared with the other four predictors (Gardner, 2001; Tabachinick, & Fidell, 2001). This result therefore can be interpreted as follows—that students who were more motivated tended to invest more mental effort. Similar patterns in the level of motivation and mental effort across the four segments (See Figure 5, p. 97) also supported this interpretation. Students showed moderate levels of motivation on the first and fourth segments, the least motivation on the second segment, and the highest motivation on the third segment, a pattern also observed in self-reported mental effort.

The part correlation between the level of mental effort and the level of prior knowledge was -0.19 indicating that students with higher levels of confidence in prior knowledge generally tended to invest less mental effort. As previously argued, it was assumed that students who were more confident in their prior knowledge about global warming were likely to have more knowledge about it. Being more knowledgeable about something means that learners already have schemata relevant to the process of comprehending and thus can invest less mental effort to understand.
Somewhat surprisingly, however, readers’ judgments about the difficulty of reading tasks were not a significant factor in predicting level of mental effort. The part correlation between the level of mental effort and the level of difficulty was 0.04, indicating almost no relationship between these two variables after the level of difficulty variability shared with the other four predictors (levels of prior knowledge about global warming, levels of confidence in the US geography, levels of confidence in Korean geography, and levels of motivation) was partialled out. Thus, it is not guaranteed that learners automatically exert more mental efforts when they deal with more difficult materials. Instead, levels of expertise should perhaps be more closely considered in determining how much mental effort will be invested (Kalyuga & Sweller, 2004). If learners consider a learning task as too easy or too difficult, they may not be eager to invest their mental effort and will quit learning. Paas, Tuovinen, van Merriënboer and Darabi (2005) stated, for instance, that “as long as a task is not too easy and not too difficult, ratings of task difficulty may correlate highly with ratings of invested mental effort” (p.32). To be a significant predictor for the level of mental effort, the level of difficulty needs to be adequate for learners to be eager to devote their mental resources. To the extent which learners consider learning material as neither too easy nor too difficult, perceived levels of difficulty could be a predictor for how much mental efforts they would exert.

Limitations and Implications

Limitations of the Current Study

One limitation of the current study is its generalizability. That is, the present findings may be limited to materials in which geographical backgrounds serve as context.
As previously discussed, context can be characterized in many ways. For instance, context has been variously defined as words (e.g., Schvaneveldt & Meyer, 1973), sentences (e.g., Kleiman, 1980), paragraphs, a whole story, settings, (e.g., Carey et al., 1981), and even more broadly, as culture (e.g., Steffensen, Joag-dev, & Anderson, 1979). Depending on how a researcher defines context, context effects on comprehension and recall could be present or not. Thus, the findings regarding the effects of context in the present study are restricted to materials in which the familiarity of geographical contexts for information is varied.

Another generalizability-related limitation is tied to the nature of multivariate analysis of covariance (MANCOVA). Tabachnick and Fidell (2001) have pointed out that the result of MANCOVA “… generalizes only to those populations from which the researcher has randomly sampled” (p.328). In the current study, participants were randomly assigned into four groups using a random number generator. Because a MANCOVA does not adjust for failure of random sampling, in order to generalize the results of MANCOVA from this study, the way of sampling should be cautiously examined.

The second limitation is that even though the results were significant, most effect sizes presented by partial $\eta^2$ were relatively small. Partial $\eta^2$ is the proportion of variance that can be predicted from one factor when the effects of the other factor and the interaction between them are partialed out (Pierce, Block, & Aguinis, 2004). Partial $\eta^2$ is generally used to determine practical importance. According to Cohen (1992), partial $\eta^2$.02 is small, 0.15 is medium and 0.35 is large. The present multivariate analysis of covariance (MANCOVA) using four groups as a between-subject factor and six
dependent variables showed small $\eta^2$ (0.08) effects. Follow-up univariate F-tests likewise showed small $\eta^2$ for levels of difficulty (0.07) and levels of inference-making (0.07), while univariate F-tests after the MANCOVA employing context as a between-subject factor showed small effect sizes including the level of inference-making (0.03), levels of self-reported motivation (0.03), and self-reported difficulty of the materials (0.07). The univariate F-test for signaling also revealed a small effect size on the inference-making outcome (0.03). The results of the present MANCOVA showed mostly small $\eta^2$. Only the multivariate result by context as a factor approached a medium effect size (0.13).

Effect sizes need to be considered in the context of each study because there is no simple and easy way for determining practical importance. Even a very small effect size can have high practical importance—for example, if the effect size shows practical importance of a study for life or death, such as pharmaceutical development. Also, the size of an effect is reliant to some extent on limitations in measurement, design and method. Not surprisingly, larger effects are generated by better measurement, design and method. If the effect size is small because of measurement errors or design and not because of real small differences between the treatment group and control group, overall methods including measurement and design should be carefully inspected (McCartney & Rosenthal, 2000).

The third limitation is that the reading materials in the present study were presented in segments, which may have reduced the effects of context and signaling. Prior to segmentation, the four versions of reading materials about global warming were quite long, around 2000 words continuously for each version. To permit examining the changes of levels of motivation, difficulty and mental effort as the participants read the
materials, however, the reading materials were divided into four parts. While allowing for measurement of variables of interest, difficulty and mental effort as students read, it may have been that segmentation may have lowered cognitive load by reducing the amount of information needing to be processed in working memory at one time (Mayer, et al., 1999; Mayer & Chandler, 2001; Moreno, 2007).

If the reading materials were not segmented, they presumably would have generated somewhat higher levels of cognitive load, especially for those participants encountering global warming information in the unfamiliar context conditions because schemata relevant to the unfamiliar geographical background would not be available. However, the amount of load imposed by unfamiliar context might have been attenuated by segmentation because the amount needing to be read at any one time was reduced (Pollock, Chandler, & Sweller, 2002). If the segmentation resulted in students’ limited working memory capacity not being exceeded or cognitive load being effectively reduced, impacts of signaling on adjusting presumed levels of cognitive load would likely be decreased. Therefore, Hypothesis 4, which was based upon an assumption that signaling would more effectively reduce cognitive load for unfamiliar context might not have been supported because of the ineffectiveness of signaling but because of cognitive load reducing effects of segmentation.

**Implications for Future Research**

The present study demonstrated that presenting an unfamiliar text context (in this case, a geographical one) for learning technical information can constitute a disadvantage for students—interfering with their deep understanding of the global warming content of the passages, increasing perceived difficulty of passages, and lowering the students’
motivation. Given the pattern of these findings, it could be inferred that students’ intrinsic load was increased and their germane load decreased due to the context unfamiliarity. Providing signaling in passages that included unfamiliar contexts generally did not compensate for these disadvantages.

From this, a first implication for future research is that other possible instructional manipulations should be examined that might compensate for the disadvantages resulting from an unfamiliar text background. For example, it likely would be valuable to closely examine the positive effects of segmentation (e.g., Hasler, Kersten, & Sweller, 2007; Moreno, 2007; Mayer & Chandler, 2001) and of building learners’ prior knowledge about unfamiliar contextual features before reading scientific content that will be embedded in an unfamiliar context. The study of Mayer, Moreno, Boire, and Vagge (1999), for instance, showed results favoring segmentation of information employed to reduce cognitive load. Students who viewed a segmented animation describing the process of lightning formation outperformed these students who viewed an unsegmented narrated animation on retention and transfer tests. Regarding the issue of unfamiliar context, the instructional approach of Pollock, Chandler, and Sweller (2002) illustrates the value of methods that build prior knowledge before learning. Their findings suggest that complex problems can be effectively approached only after students’ appropriate prior knowledge is built.

The second implication of the present study for future research is that possible indirect ways to measure levels of intrinsic load and germane load were suggested by the methods and findings of the current study. In CLT, it is important to clearly understand the three sources of cognitive load and that the sum of these sources should not exceed
learners’ working memory capacities (van Merriënboer & Sweller, 2005; Sweller, 2005). It is not possible to measure the three different kinds of load directly. What is possible, however, is to indirectly measure the different kinds of load through other avenues.

For the measurement of levels of germane load, for instance, the present researcher proposed that assessments of self-reported levels of motivation could be used as an index of germane cognitive load. If one condition of an experiment increases both learners’ levels of motivation and their performances, levels of motivation presumably can be an indication of levels of germane load invested in that condition (Paas, Renkl, & Sweller, 2003). This conclusion is based on the logic that if learners are more motivated by a condition, the resulting higher motivation can lead to the investment of more mental effort relevant to learning and in turn to enhanced performance. If a condition increases only the level of motivation but learners’ performance is the same or decreased, however, level of motivation cannot be a factor to indicate the level of germane load invested.

If intrinsic load is assessed by element interactivity (van Merriënboer & Sweller, 2005), it likewise is almost impossible to directly measure element interactivity in a material for each learner. The current study showed, however, that learners’ self-reported levels of difficulty could serve as an indirect indicator of intrinsic load imposed by the materials. If learners in one condition perceive that they are experiencing more difficulty and it is possible to interpret that the condition is likely to contribute to the increase of element interactivity, the learners’ levels of difficulty may indicate the level of intrinsic load imposed by the material. It is believed that the approach suggested by the current study for measuring levels of germane load and intrinsic load indirectly can provide a valuable addition to research on CLT.
In the present study, it was not always clear whether learners’ levels of mental effort gauged the amount of overall cognitive load or one of the three different kinds of load imposed by the manipulation of context and signaling. Self-reported levels of mental effort by themselves are not enough to show how the sum of cognitive load or individual dimensions of cognitive load are being affected by the instructional manipulations of context and signaling. Future studies are needed that clarify the relationship among germane load, intrinsic load, and extraneous load and the ways to measure of each type of cognitive load and their sum.

A third implication from this study is that learners’ levels of prior knowledge must be considered when any instructional technique is applied to learners. An expertise reversal effect was demonstrated in the current study, where signaling had a negative effect on students’ deep understanding in the high-prior knowledge group, but helped students’ deep understanding in the low-prior knowledge group. According to Kalyuga, et al. (2003), highly guided instructional material can be redundant for more experienced learners, even though it is essential for less experienced learners. That is, instructional techniques that are effective for less experienced learners can lose their effectiveness or lead to negative learning outcomes as learners become more experienced and expert (e.g., McNamara et al., 1996; Tuovinen & Sweller, 1999). It also would seem highly desirable to examine what kind of cognitive process (e.g., shallow comprehension, deep comprehension, and simple recall) is the target of the instructional techniques.

For future research related to the third implication, it is important that any manipulation fostered to compensate disadvantages caused by unfamiliar context be examined in conjunction with learners’ levels of prior knowledge. An investigation of the
relationship between segmentation and learners’ prior knowledge could be one possibility. It also would be interesting to examine whether segmenting a learning material is beneficial for more experienced learners as contrasted to less experienced learners.

Results from the current study showed that signaling negatively affected only deep understanding, and then only for the learners with higher prior knowledge of the Korean geographical context. Fact-level learning and recall were not hindered by signaling in any group. Therefore, it would be also valuable in future research to examine the relationship among instructional techniques, kinds of learners’ cognitive process, and learners’ levels of expertise. An investigation about how instructional techniques affect different learner’s cognitive processes depending on levels of learners’ expertise would be important in many educational settings.

Conclusions

The effect of context on comprehension and recall has been defined variously in previous research and examined in many prior studies. The current study extended the scope of context related variables in text learning by defining it in terms of a geographical setting for information that was expected to be either more or less familiar to readers. To this writer’s knowledge, it is among the first to explore the learning and recall of technical information (on global warming phenomena) presented and illustrated by examples drawn from different geographical background contexts (familiar American context and unfamiliar Korean context). Findings of this study also were interpreted from the perspective of CLT. The results of the current study supported the predictions that a familiar setting for encountering new, technically-oriented information would facilitate
readers’ comprehension and reduce their cognitive load whereas an unfamiliar contextual framework would reduce their understanding and increase cognitive load.

For example, the students in familiar context conditions showed a higher level of inference-making (deep comprehension), higher self-reported levels of motivation, and lower perceived levels of difficulty than the students in unfamiliar context conditions. The results were interpreted by the perspective of CLT. It also was inferred that students’ higher self-reported levels of motivation in familiar context conditions contributed to increasing germane load invested because the higher levels of motivation lead to a higher performance of inference-making. In general, students’ lower perceived levels of difficulty in the familiar context conditions were attributed to low element interactivity, as an aspect of intrinsic load. However, an expectation that offering signaling devices would compensate for higher cognitive load and lower performances caused by the unfamiliar context conditions was not generally supported. Rather, a negative signaling effect was detected on inference-making. Further examination found out an expertise reversal effect. Providing signaling devices interfered with students’ deep understanding in a high-prior knowledge group while they enhanced students’ deep understanding in a low-prior knowledge group.

The current study suggests several potential ideas for future research. Among these are examining ways to compensate for disadvantages resulted from information situated in an unfamiliar context, scrutinizing the relationship among three kinds of load and the measurement of them, and considering levels of learners’ expertise in any new instructional manipulation. More research is needed to identify relationships among instructional techniques, the kinds of learners’ cognitive process (e.g., deep
comprehension or recall) that are the target of any intervention, and learners’ levels of expertise.
References


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McKeown, M. G. (1985). The acquisition of word meaning from context by children of


Appendix A

Checklist of Demographic Information

Gender: ( ) Male

( ) Female

Age: (     )

Which year are you in?

( ) Freshman

( ) Sophomore

( ) Junior

( ) Senior

( ) Graduate

Major: (     )
Appendix B

Prior Knowledge about Global Warming

1-Item Self-Rating

How much knowledge do you have about global warming?

1  2  3  4  5

( )----------------( )----------------- ( )-----------------( )-----------------( )

Very Little  Little  Average  Much  Very Much

Students’ Efficacy for Knowledge about Global Warming

Using the 0 to 100 scale provided below, please rate how confident you are that you can do each of the things described in the following six items by writing the appropriate number in the space provided. For each item, you can select any number between 0 and 100 (e.g., 35, 60, 87) as your choice.

0  10  20  30  40  50  60  70  80  90  100

Absolutely No confidence that I can do this

Moderate Confidence that I can do this

Completely certain that I can do this

1. How confident are you that you can state a cause of global warming

2. How confident are you that you can describe 2 consequences of global warming?

3. How confident are you that you can accurately describe the
greenhouse effect?

4. How confident are you that you can name at least 2 "greenhouse" gases? 

5. How confident are you in stating why scientists are concerned about global warming? 

6. How confident are you that global warming is really occurring?
Appendix C

Students’ Efficacy for Knowledge about American and Korean Geography

Using the 0 to 100 scale provided below, please rate how confident you are that you can do each of the things described in the following six items by writing the appropriate number in the space provided. For each item, you can select any number between 0 and 100 (e.g., 35, 60, 87) as your choice.

<table>
<thead>
<tr>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
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<th>70</th>
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<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutely No confidence that I can do this</td>
<td>Moderate Confidence that I can do this</td>
<td>Completely certain that I can do this</td>
<td></td>
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<td></td>
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1. How confident are you that you can name four major cities in the US? ________

2. How confident are you that you can name four major cities in South Korea? ________

3. How confident are you that you can name the ocean to the east and west of the US? ________

4. How confident are you that you can name the ocean to the east and west of South Korea? ________

5. How confident are you that you can point to where the Rocky Mountains are located on a map of the US? ________

6. How confident are you that you can point to where the Korea ________
Peninsula is located on a map of Asia?

7. How confident are you that you can name the capital city of the US?

8. How confident are you that you can name the capital city of South Korea?
Global Warming refers to the continuous increase in the average measured temperature of the earth’s atmosphere and its oceans. It is important to understand global warming because more and more people are concerned about how global warming will affect their health and the well-being of current and future generations. Most scientists agree that the temperature increase can permanently change the earth’s climate and that climate change is one of the most serious challenges to our future well-being. Also, these scientists have concluded that there is a significant human influence on climate change.

Globally, a warmer earth will bring about increases in temperatures, increases in precipitation, increases in the strength of tropical cyclones, and cause rises in sea level. Researchers think that greenhouse gases and greenhouse effect are largely responsible for global warming. Global warming also leads to a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease, and increases in ground-level ozone. In this essay, employing examples from the US, the causes and impacts of global warming in America and in general will be addressed in detail.
**Increases in Temperature** → (Heading & Boldface)

In America, the average temperature has been increasing and the rate of change has accelerated since 1983. The seven warmest years in history have occurred since 1990. During that period, temperatures have been above average across most of the United States, with temperatures in Colorado, Wyoming, and Utah much above normal for winter in 2004 and 2005. Also, much-above-average temperatures were observed in California, Nevada and Arizona during summer. A new record of seven consecutive days at or above 125°F was observed in July 2005 at Death Valley, California.

These phenomena show that the US is not an exception of global warming. According to a report by the Intergovernmental Panel on Climate Change (IPCC), globally, our planet has warmed about 1.3 °F in the twentieth century. Moreover, according to research at the Massachusetts Institute of Technology, the twentieth century was the warmest in the last 1,000 years. Based upon previous reports, IPCC estimates that global average temperatures could increase by about 3°F to 10°F by 2100.

**Increases in Precipitation** → (Heading & Boldface)

Increasing temperatures of air and sea surface due to global warming tends to increase evaporation, with the increase in evaporation then leading to increases in precipitation. The US has experienced an increase in precipitation as well. The US average precipitation in 2005 was 29.7 inches, well above the long-term (1895–2005) mean of 29.1 inches. Specifically, December 2004 through February 2005 was very wet from the California coast through the Plains and into the Great Lakes and Northeast. There also was much-above-normal precipitation around the west Coast. Six northeastern
states, such as Maine, Vermont, and New Hampshire, reported their wettest fall on record. In addition, Mt. Washington set a record for the greatest October snowfall (78.7 inches), exceeding the previous record set back in 2000 by 40.2 inches.

Likewise, increases in precipitation can be observed globally. The research group at University College London has recorded precipitation over land, with their data showing that precipitation has increased by about 2 percent globally since 1900.

**Increases in Strength of Tropical Cyclones (Hurricanes and Typhoons)**

The strength of tropical cyclones (hurricanes and typhoons) also has been increasing. In 2004 and 2005, Hurricanes Katrina, Rita, and a parade of storms affected the US. They devastated parts of Southern states such as Mississippi, Louisiana, and Texas. The apparent recent increase in hurricane intensity and duration measures in the Atlantic basin and several other basins has received considerable attention. Hurricane Katrina left Florida as a Category 1 hurricane but after a few days, Katrina transformed herself from a mild tropical storm into a dangerous Category 5 hurricane as she spun through the warm waters of the Gulf of Mexico. Hurricane Katrina killed 1,836 people and left $80 billion in damage, making it the worst hurricane ever.

Studies conducted by the University of Tokyo in Japan have shown that a combined measure of both the duration and intensity of tropical cyclones has doubled over the last 30 years. This trend corresponds to increases in average ocean surface temperature. Most of the strongest cyclones on record have occurred during the past 10 years just as ocean surface temperatures have reached record levels. Thus,
the increases in ocean surface temperature seem likely to be responsible for the most severe cyclones on record.

A number of researchers have presented evidence that global warming is a crucial factor that causes the increase in cyclones’ intensity and duration. Professor James Elsner at Florida State University, for example, found that average air temperatures during cyclone seasons between June and November predict sea surface temperatures, which are a vital component in nourishing cyclone winds, but not vice-versa. His analysis provides verification of a link between atmospheric warming and the recent upswing in frequency and intensity of cyclones. According to his analysis, future tropical cyclones (typhoons and hurricanes) are likely to become more intense with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

Rises in Sea Level

Globally, a significant amount of sea level rise has been observed and that likely has resulted from the observed warming of the atmosphere and the oceans. Rises in sea level has been also observed in the US, with sea level rising about 0.1 inch per year along most of the US Atlantic and Gulf coasts. This rise is part of the effects in which a warmer earth has globally influenced sea level.

Sea level, as estimated by a research team at University of Amsterdam in the Netherlands using tide gauge measurements, has risen approximately 6-8 inches worldwide during the last century. Furthermore, this research team found that the expansion of ocean water, the melting of mountain glaciers,
and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.

Glacier National Park in Montana is a good example of the melting mountain glaciers. The glacier has been retreating rapidly since the early 1900's. At the current rate of melting, all glaciers will be gone at Glacier National Park by the middle of the next century. Mountain glaciers are one of the excellent sources that monitor climate change. The universal shrinkage of mountain glaciers is thought to be caused by a combination of increases in temperature and greenhouse-gas emissions.

**Greenhouse Gases and Greenhouse Effect** → (Heading & Boldface)

Most scientists believe that the primary reason for global warming are the so-called “greenhouse gases.” The most important greenhouse gases are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). They are mostly produced by human activities. A study conducted by a research team at University of Oxford → (Boldface) in England verified this supposition. The study shows that human activities, for example, burning coal, oil and gas, and cutting down forests are largely responsible for increasing greenhouse gases.

The primary greenhouse gas emitted by human activities in the US is carbon dioxide (CO₂), which represents about 85 percent of the total greenhouse gas emissions. Carbon dioxide (CO₂) has been emitted mostly by the combustion of fossil fuels. According to the US Environmental Protection Agency (EPA), total US greenhouse gas emissions have risen by about 16 percent from 1990 to 2004. In 2004, they increased by about 2 percent from the previous year and it is expected that this trend will continue into the future. Due to continuous increases in greenhouse gas emissions, some states initiated
action on decreasing such emissions. On February 26, 2007, the Governors of Arizona, California, New Mexico, Oregon, and Washington signed an agreement establishing the Western Climate Initiative 3 in order to reduce greenhouse gas emissions.

Greenhouse gases play an important role in absorbing and emitting heat. Excessive greenhouse gases strengthen greenhouse effect, which refers to a global increase in temperatures as heat energy from sunlight is trapped. A stronger greenhouse effect will increase the rate of global warming. Thus, it is expected that global warming will be accelerated as increases in greenhouse gas emissions strengthen greenhouse effect.

**Impacts on Wildlife**

Global warming is also a dangerous threat to the future of wildlife. The American eco-system is no exception. In the past 40 years, there has been an increase in catches of warm water fish and a decrease in the catches of cold water fish. As North American temperatures continue to rise, cold water fish such as trout are losing their current habitats. Trout habitat throughout the Rocky Mountain region may be reduced by 50 percent or more by the end of the century. In contrast, warm water fish such as bass and tilapia, have begun to infiltrate to places like Monterey, California, which previously were dominated by colder water species.

As shown in the example above, plants and animals around the world are in real danger of falling victim because their habitats are changing too rapidly for them to keep up. According to plant and animal scientists at University of Laval in France, as many as one-third of all wildlife species in some parts
of the world could be headed toward extinction within the next 50 years due to global warming.

**Impacts on Human Health**

**Extreme heat waves.** Climate change can directly affect human health by increasing the number of extreme heat waves. For example, during the 1990s, Chicago experienced several severe heat waves. In July 1995, a heat wave resulted in 485 heat-related deaths and 739 excess deaths when the temperature was over 98°F for 4 days. After consecutive heat events, Chicago implemented a Heat Health Watch/Warning System. The warning system was implemented in other US cities such as Cincinnati, New Orleans, and St. Louis.

According to a study conducted by a research center at University of Chicago, increases in temperature may lead to more extreme heat waves during summer. Heat waves are rare events that vary in character and impact, but they could become more frequent, intense, and long-lasting with global warming.

**Increases in waterborne disease.** Scholars from National University of Singapore pinpointed that global warming is likely to increase waterborne diseases. Some examples can be found in the US. A soaking rain in Milwaukee in 1993 caused a sewage release that resulted in the deaths of 54 people. In the summer of 2004, more than 1400 people reported gastrointestinal problems linked to several months of above-average rainfall on Ohio's South Bass Island in Lake Erie. These examples can be explained by deducing that global warming is likely to cause heavy rainfall, the heavy rainfall will trigger sewage overflows, and in turn contaminate drinking water.
Increases in ground-level ozone. Global warming leads to more frequent high temperatures, which are likely to cause increases in ground-level ozone. Several big cities in the US report the possible danger of increases in ground-level ozone. On the days when ozone levels are high, emergency room visits for asthma attacks in big cities, such as New York, Los Angeles and Chicago, have been shown to increase by as much as 36 percent. According to a research team in Korea’s Seoul National University, ozone is a severe irritant that can cause choking, coughing, and stinging eyes. Moreover, it damages lung tissue, aggravates respiratory disease, and makes people more susceptible to respiratory infections. In fact, the increase in ground-level ozone is especially harmful for those with asthma and other chronic lung diseases.

So far, the phenomena tied to global warming and examples from the US have been reviewed. In summary, the strong causes of global warming are likely to be green house gases emitted by human activities. Global warming could influence so many areas surrounding human beings such as increases in temperature, precipitation, strength of tropical cyclones, and rises in sea level. Also, it is expected that a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease and ground-level ozone. Many threatening examples of global warming’s effects have been observed already in the US. This means that urgent measures are needed to prevent global warming or slacken the progress of global warming. Therefore, now is the right time to concern about global warming for ourselves and future generations.
Global Warming → (Title & Boldface)  
(Korean Version)  

* The grey-highlighted parts are different in two versions (American vs. Korean) to provide two different contexts  
* The yellow-highlighted parts will be inserted only for the signaling version (Red-colored words indicates what kind of signaling is being used)  

Global warming refers to the continuous increase in the average measured temperature of the earth’s atmosphere and its oceans. It is important to understand global warming because more and more people are concerned about how global warming will affect their health and the well-being of current and future generations. Most scientists agree that the temperature increase can permanently change the earth’s climate and that climate change is one of the most serious challenges to our future well-being. Also, → (Logical connectives) these scientists have concluded that that there is a significant human influence on climate change.

Globally, a warmer earth will bring about increases in temperatures, increases in precipitation, increases in the strength of tropical cyclones, and cause rises in sea level. Researchers think that greenhouse gases and greenhouse effect are largely responsible for global warming. Global warming also leads to a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease, and increases in ground-level ozone → (Preview) In this essay, employing examples from Korea, the causes and impacts of global warming in America and in general will be addressed in detail.
The Increases in Temperature → (Heading & Boldface)

In Korea, the average temperature has been increased and the rate of change has accelerated since 1990. The five warmest years in history have occurred since 1995. During that period, temperatures have been above average across most of Korea with temperatures in Busan, Chunan and Gwangju much above normal for winter in 2004 and 2005. Also, much-above-average temperatures were observed in Seoul, Guri, and Suwon during summer. A new record of five consecutive days at or above 34°C was observed in August 2005 in Daegue, Gyeongsangbuk-do.

These phenomena show that Korea is not an exception of global warming. According to a report by the Intergovernmental Panel on Climate Change (IPCC), globally, our planet has warmed about 1.3 °F in the twentieth century. Moreover, according to research at the Massachusetts Institute of Technology, the twentieth century was the warmest in the last 1,000 years. Based upon previous reports, IPCC estimates that global average temperatures could increase by about 2°C to 6°C by 2100.

Increases in Precipitation → (Heading, Bold)

Increasing temperatures of air and sea surface due to global warming tends to increase evaporation, with the increase in evaporation then leading to increases in precipitation. Korea has experienced an increase in precipitation. The average precipitation in 2005 was 1464.8 mm, well above the long-term (1971–2000) mean of 1440.2 mm. Specifically, June 2005 through August 2005 was very wet from Taeback province through Joongbu and into Youngdong province. There also was much-above-normal precipitation around Daegwallyeong and Gangneung city. Six cities in
Youngdong province, such as Gangneung, Donghae, and Chuncheon, reported their wettest summer on record. In addition, Youngdong providence set a record for the heaviest rainfalls per hour of 100.5 mm, exceeding the previous record set back in 2000 by 20.8 mm.

Likewise, increases in precipitation can be observed globally. The research group at University College London has recorded precipitation over land, with their data showing that precipitation has increased by about 2 percent globally since 1900.

**Increases in Strength of Tropical Cyclones (Hurricanes and Typhoons)**

The strength of tropical cyclones (typhoons and hurricanes) also has been increasing. In 2002 and 2003, Typhoons Maemi, Rusa and a parade of typhoons affected Korean Peninsula. They devastated parts of southern regions such as Gyeongsangbuk-Do, Gyeongsangnam-Do and Jeju-Do. The apparent recent increase in some typhoon intensity and duration measures in East Sea and South Sea of Korea has received considerable attention. Typhoon Maemi was a powerful supertyphoon that struck South Korea. At first, it was a Category 4 typhoon with the speed of 130 km per hour winds. After reaching a Category 5, the peak of winds became 150 km per hour. Maemi killed 115 people and left ₩5 Cho in damage, making it the worst typhoon ever.

Studies conducted by the University of Tokyo in Japan have shown that a combined measure of both the duration and intensity of tropical cyclones has doubled over the last 30 years. This trend corresponds to increases in average ocean surface temperature. Most of the strongest cyclones on record have occurred during the
past 10 years just as ocean surface temperatures have reached record levels. **Thus,** (Logical connectives) the increases in ocean surface temperature seem likely to be responsible for the most severe cyclones on record.

A number of researchers have presented evidence that global warming is a crucial factor that causes the increase in cyclones’ intensity and duration. Professor James Elsner at **Florida State University** (Boldface), **for example,** (Logical connectives) found that average air temperatures during cyclone seasons between June and November predict sea surface temperatures, which are a vital component in nourishing cyclone winds, but not vice-versa. His analysis provides verification of a link between atmospheric warming and the recent upswing in frequency and intensity of cyclones. According to his analysis, future tropical cyclones (typhoons and hurricanes) are likely to become more intense with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

**Rises in Sea Level** (Heading & Boldface)

Globally, a significant amount of sea level rise has been observed and that likely has resulted from the observed warming of the atmosphere and the oceans. **Rises in sea level** has been also observed in Korea, with sea level rising about 5.7mm per year, which is much larger than the global rate. This rise is part of the effects in which a warmer earth has globally influenced sea level.

Sea level, as estimated by a research team at **University of Amsterdam** (Boldface) in the Netherlands using tide gauge measurements, has risen approximately 15-20 centimeters worldwide during the last century. **Furthermore,** (Logical connectives) this research team found that the expansion of ocean water, the melting of
mountain glaciers, and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.

**Baekdu Mountain in Hamkyungdo** is a good example of the melting mountain glaciers. The glacier has been retreating rapidly since the early 1900's. At the current rate of melting, all glaciers will be gone from Chunjiyun in Baekdu National park by the middle of the next century. Mountain glaciers are one of the excellent sources that monitor climate change. The universal shrinkage of mountain glaciers is thought to be caused by a combination of increases in temperature and greenhouse-gas emissions.

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Most scientists believe that the primary reason for global warming are the so-called “greenhouse gases.” The most important greenhouse gases are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). They are mostly produced by human activities. A study conducted by a research team at University of Oxford in England verified this supposition. The study shows that human activities, for example, burning coal, oil and gas, and cutting down forests are largely responsible for increasing greenhouse gases.

The primary greenhouse gas emitted by human activities in Korea is carbon dioxide (CO₂), which represents about 90 percent of total greenhouse gas emissions. Carbon dioxide (CO₂) has been emitted mostly by the combustion of fossil fuels. According to Ministry Environment Republic of Korea, total Korea greenhouse gas emissions have risen by about 18 percent from 1990 to 2004. In 2004, it is increased by about 3 percent from the previous year and it is expected that this trend will continue into the future. Due to continuous increases in greenhouse gas emissions, several big Korean
cities initiated an action on decreasing such emissions. On July 10, 2008, the energy policy directors of Seoul, Busan, Gwangju, Incheon, and Daegu had a meeting regarding detailed methods and procedures in order to reduce greenhouse gas emissions.

Greenhouse gases play an important role in absorbing and emitting heat. Excessive greenhouse gases strengthen greenhouse effect, which refers to a global increase in temperatures as heat energy from sunlight is trapped. A stronger greenhouse effect will increase the rate of global warming. Thus, it is expected that global warming will be accelerated as increases in greenhouse gas emissions strengthen greenhouse effect.

**The Impacts on Wild Life**

Global warming is also a dangerous threat to the future of wildlife. The Korean eco-system is no exception. In the past 40 years, there has been an increase in catches of subtropical fish and a decrease in the catches of cold water fish. As Donghae (the East Sea) temperatures continue to rise, cold water fish such as cod are losing their current habitats. Cod habitat throughout North Donghae region may be reduced by 30 percent or more by the end of the century. However, subtropical fish such as squid and mackerel that were usually found around Jeju Island made their way up to the northeastern shores of Busan.

As shown in the example above, plants and animals around the world are in real danger of falling victim because their habitats are changing too rapidly for them to keep up. According to plant and animal scientists at University of Laval in France, as many as one-third of all wildlife species in some parts
of the world could be headed toward extinction within the next 50 years due to global warming.

**The Impacts on Human Health**

**Extreme heat waves.** Climate change can directly affect human health by increasing the number of extreme heat waves. For example, during the 1990s, Seoul experienced several severe heat waves. In July 1994, a heat wave resulted in 254 heat-related deaths and 532 excess deaths when the temperature was over 38 ºC for 14 days. After consecutive heat events, Seoul implemented a Heat Health Watch/Warning System. The warning system was implemented in other Korean cities such as Busan, Chunan, and Gwanju.

According to a study conducted by a research center at University of Chicago, increases in temperature may lead to more extreme heat waves during summer. Heat waves are rare events that vary in character and impact, but they could become more frequent, intense, and long-lasting with global warming.

**Increases in waterborne disease.** Scholars from National University of Singapore pinpointed that global warming is likely to increase waterborne diseases. Some examples can be found in Korea. A soaking rain in Daegu in 1993 caused a sewage release that resulted in the deaths of 23 people. In the summer of 2004, more than 700 people reported gastrointestinal problems linked to several months of above-average rainfall on the area around Nakdong river in Kyungsangbuk-do. These examples can be explained by deducing that global warming is likely to cause heavy rainfall, the heavy rainfall will trigger sewage overflows, and in turn, contaminate drinking water.
**Increases in ground-level ozone.** Global warming leads to more frequent high temperatures, which are likely to cause increases in ground-level ozone. Several big cities in Korea report the possible danger of increases in ground-level ozone. On the days when ozone levels are high, emergency room visits for asthma attacks in big cities, such as Seoul, Inchon, Busan and Gwangju, have been shown to increase by as much as 28 percent. According to a research team in Korea’s **Seoul National University**, ozone is a severe irritant that can cause choking, coughing, and stinging eyes. Moreover, it damages lung tissue, aggravates respiratory disease, and makes people more susceptible to respiratory infections. In fact, the increase in ground-level ozone is especially harmful for those with asthma and other chronic lung diseases.

So far, the phenomena tied to global warming and the examples from Korea have been reviewed. In summary, the strong causes of global warming are likely to be green house gases emitted by human activities. Global warming could influence so many areas surrounding human beings such as increases in temperature, precipitation, strength of tropical cyclones, and rises in sea level. Also, it is expected that a wide range of impacts on wildlife and human health such as extreme heat waves, increases in waterborne disease and ground-level ozone. Many threatening examples of global warming’s effects have been observed already in Korea. This means that urgent measures are needed to prevent global warming or slacken the progress of global warming. Therefore, now is the right time to be concerned about global warming for ourselves and future generations.
Appendix E

Subjective Rating Scale

How interesting was the information you learned in SEGMENT No. (after each segment) or ALL FOUR SEGMENTS (after reading all segments)?

<table>
<thead>
<tr>
<th>Boring</th>
<th>Interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( )-----( )---------( )---------( )---------( )</td>
<td></td>
</tr>
</tbody>
</table>

How eager were you to learn about the information in SEGMENT No. (after each segment) or ALL FOUR SEGMENTS (after reading all segments)?

<table>
<thead>
<tr>
<th>Not Eager</th>
<th>Very Eager</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( )---------( )---------( )---------( )---------( )</td>
<td></td>
</tr>
</tbody>
</table>

How difficult was it to learn the information in SEGMENT No. (after each segment) or ALL FOUR SEGMENTS (after reading all segments)?

<table>
<thead>
<tr>
<th>Not Difficult</th>
<th>Very Difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( )---------( )---------( )---------( )---------( )</td>
<td></td>
</tr>
</tbody>
</table>

How much effort did you put into learning the information SEGMENT No. (after each segment) or ALL FOUR SEGMENTS (after reading all segments)?

<table>
<thead>
<tr>
<th>No Effort</th>
<th>A Lot of Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>( )---------( )---------( )---------( )---------( )</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F

Fact-Related Comprehension Questions, a Recall Question, and Inference Making Questions
(Red-colored choice - the right answer)

Comprehension Questions

Global warming

Fact 1
Global warming refers to the continuous increase in the average measured temperature of the earth’s atmosphere and its oceans.

Global warming refers to the continuous increase in the average measured temperature of the earth’s

a. atmosphere
b. oceans
c. atmosphere and oceans
d. atmosphere, oceans, and mountains

Fact 2

Scientists have concluded that there is a significant human influence on climate change.

Scientists have concluded that human influence on climate change is

a. infrequent
b. significant
c. small
d. unobservable

Increases in temperature

Fact 3

According to research at the Massachusetts Institute of Technology, the 20th century was the warmest in the last 1000 years.
According to research at the Massachusetts Institute of Technology, the 20th century was the warmest in the last

a. 100 years  
b. 500 years  
c. 1000 years  
d. 5000 years

Fact 4

The IPCC estimates that global average temperatures could increase by about 3°F to 10°F (2°C to 6°C) by 2100.

(American version)
Approximately how many degrees is the temperature expected to increase on our planet by 2100?

a. From 1 to 8 ºF  
b. From 2 to 11 ºF  
c. From 3 to 10 ºF  
d. From 4 to 11 ºF

(Korean version)
Approximately, how many degrees is the temperature expected to increase on our planet by 2100?

a. From 1 to 5 ºC  
b. From 1 to 6 ºC  
c. From 2 to 6 ºC  
d. From 3 to 7 ºC

Fact 5

Intergovernmental Panel on Climate Change (IPCC)

What does IPCC stand for?

a. Interstate Panel on Climate Change  
b. Intergovernmental Panel on Climate Change  
c. International Panel on Climate Change  
d. Interregional Panel for Climate Change
Increases in precipitation

Fact 6

Precipitation over land has increased by about 2 percent globally since 1900.

About how much has precipitation over land increased globally since 1900?

a. 1 percent  
b. 2 percent  
c. 3 percent  
d. 4 percent

Fact 7

Increasing temperatures of air and sea surface due to global warming tends to increase evaporation, with the increase in evaporation then leading increases in precipitation.

Increasing temperatures of air and sea surface affect ______ in evaporation and ______ in precipitation.

a. increases, increases  
b. increases, decreases  
c. decreases, increases  
d. decreases, decreases

Increase in Strength of Tropical Cyclones (Hurricanes and Typhoons)

Fact 8

The increases in ocean surface temperature seem likely to be responsible for the most severe cyclones on record.

Which of the following is most likely responsible for stronger cyclones?

a. Stronger tornados  
b. More humid atmosphere  
c. Higher land surface temperatures  
d. Higher ocean surface temperatures
Fact 9

Average air temperatures during cyclone seasons between June and November predict sea surface temperatures, which are a vital component in nourishing cyclone winds.

Which of the following is accurately reflects the relationship between average air temperature and sea surface temperature during the June to November cyclones season?

a. Sea surface temperature is useful in predicting average air temperature  
b. Average air temperature is useful in predicting sea surface temperature  
c. Average air temperature and sea surface temperature are only occasionally related  
d. Average air temperature has no relationship to sea surface temperature

Fact 10

Future tropical cyclones (typhoons and hurricanes) are likely to become more intense with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

It is likely that future tropical cyclones will become

a. less intense  
b. more intense  
c. less frequent  
d. none of the above

Rises in Sea Level

Fact 11

Sea level is estimated by tide gauge measurements.

One important way of calculating sea level increases is by

a. testing sea depth  
b. estimating the amount of sea water  
c. tide gauge measurements  
d. careful studies of the health of coral reefs
Fact 12

The research team found that the expansion of ocean water, the melting of mountain glaciers and the melting of polar ice sheets are the primary factors driving the past century’s sea level rise.

Which of the following is *not* a primary factor contributing to the past century’s sea level rise?

a. Expansion of ocean water  
b. Melting of mountain glaciers  
c. Melting of polar ice sheets  
d. Increase in ocean salinity

Fact 13

A significant amount of sea level rise likely has resulted from the observed warming of the atmosphere and the oceans.

A significant amount of sea level rise has resulted from the warming of the

a. atmosphere and the lands  
b. oceans and the lands  
c. mountains and the oceans  
d. atmosphere and the oceans

Greenhouse gases and greenhouse effect

Fact 14

The most important greenhouse gases are carbon dioxide (CO$_2$) methane (CH$_4$) Nitrous oxide (N$_2$O).

The most important greenhouse gases are

a. carbon dioxide (CO$_2$), methane (CH$_4$), and nitrous oxide (N$_2$O).  
b. hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and hexafluoride (SF$_6$)  
c. methane (CH$_4$), hydrofluorocarbons (HFCs), and nitrous oxide (N$_2$O)  
d. carbon dioxide (CO$_2$) perfluorocarbons (PFCs), nitrous oxide (N$_2$O)
Fact 15

Human activities, for example, burning coal, oil and gas, and cutting down forests are largely responsible for increasing greenhouse gases

Which one of these human activities is not a primary factor in increasing greenhouse gases?

a. Burning coal
b. Driving cars
c. Cutting down forests
d. Cultivating farmland

Fact 16

Greenhouse gases play an important role in absorbing and emitting heat.

Greenhouse gases absorb and emit

a. heat
b. light
c. smoke
d. sound

Fact 17

The greenhouse effect which refers to a global increase in temperatures as heat energy from sunlight is trapped.

What is the natural phenomenon referring to an increase in temperatures as heat energy from sunlight is trapped?

a. Solar magnetism
b. Greenhouse effect
c. Global heat waves
d. The Kuiper Belt
Fact 18

Excessive greenhouse gases strengthen greenhouse effect. A stronger greenhouse effect will increase the rate of global warming. Thus, global warming will be accelerated as the increases of greenhouse gases strengthen greenhouse effect.

Which one does describe the right sequence of causes and effects of increases in greenhouse gas emissions?

a. Greenhouse gas emissions → global warming → greenhouse effect
b. Global warming → greenhouse gas emissions → greenhouse effect
c. Greenhouse effect → global warming → greenhouse gas emissions
d. Greenhouse gas emissions → greenhouse effect → global warming

Impacts on wildlife

Fact 19

Plants and animals around the world are in real danger of falling victim because their habitat is changing too rapidly for them to keep up.

What is the greatest threat to plants and animals caused by global warming?

a. Significant increases in precipitation.
b. Contamination of water-related resources
c. Rapid changes in their habitats.
d. Expansion of collecting and hunting areas

Fact 20

According to plant and animal scientists in University of Laval in France, as many as one-third of all wildlife species in some parts of the world could be headed toward extinction within the next 50 years due to global warming.

According to plant and animal scientists, in some parts of the world, as many as all wildlife species could be headed toward extinction due to global warming

a. 1/5
b. 1/3
c. 2/3
d. 9/10
Impacts on human health

*Extreme heat waves*

**Fact 21**

**Heat waves could become more frequent, intense and longer with global warming.**

Heat waves could become

a. Frequent, intense, long-lasting  
b. Frequent, weak, shorter  
c. Rare, intense, long-lasting  
d. Rare, weak, shorter

*Increases in waterborne diseases*

**Fact 22**

**Global warming is likely to cause heavy rainfall in the future and as a result, that will trigger sewage overflows and contaminate drinking water.**

Which one does describe the right sequence of causes and effects of heavy rainfall?

a. Sewage overflows $\rightarrow$ drinking water contamination $\rightarrow$ waterborne diseases  
b. Waterborne diseases $\rightarrow$ drinking water contamination $\rightarrow$ Sewage overflows  
c. Drinking water contamination $\rightarrow$ waterborne diseases $\rightarrow$ Sewage overflows  
d. Waterborne diseases $\rightarrow$ Sewage overflows $\rightarrow$ drinking water contamination

*Increases in ground-level ozone*

**Fact 23**

**The increase of ground-level ozone is especially harmful for those with asthma and other chronic lung diseases.**

Of the following, who are likely to be most affected by ground-level ozone?

a. People with undiagnosed heart diseases  
b. People with chronic lung diseases  
c. People with migraine headaches  
d. Disabled people who are less mobile
Comprehensive Questions

Question 24

Which is *not* a phenomenon caused by global warming?

a. Increases in precipitation  
b. Rises in sea level  
c. More intense tropical cyclones  
d. Increases in greenhouse gases

Question 25

Which one is *not* one of the negative effects on human health caused by global warming?

a. Heat-related deaths  
b. Diabetes  
c. Waterborne disease  
d. Respiratory disease

Inference Making Questions

Fact 26

Professor James Elsner at Florida State University, for example, found that average air temperatures during cyclone seasons between June and November predict sea surface temperatures, which are a vital component in nourishing cyclone winds, but not vice-versa. His analysis provides verification of a link between atmospheric warming and the recent upswing in frequency and intensity of cyclones. According to his analysis, future tropical cyclones (typhoons and hurricanes) are likely to become more intense with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

26. X and Y are cities located on the shore of the ocean. During the last ten years, X city has experienced increases in the average atmospheric temperature whereas the average temperature of Y city has been steady or a little decreased. Which city do you think is likely to be exposed to stronger hurricanes?

a. X  
b. Y  
c. Both X and Y  
d. Neither X and Y
Fact 27

Increasing temperatures of air and sea surface due to global warming tends to increase evaporation, with the increase in evaporation then leading increases in precipitation. Mountain glaciers are one of the excellent sources that monitor climate change. The universal shrinkage of mountain glaciers is thought to be caused by a combination of a temperature increase and by increased greenhouse-gas emissions.

27. X mountain national park famous for mountain glaciers has had a problem decreasing mountain glaciers. Which action is needed to slow down melting mountain glaciers?

a. Prohibiting entering the mountain glacier areas
b. Informing people the effects of greenhouse gases on mountain glaciers
c. Educating tourists about the danger of forest fire
d. None of above

Fact 28

The most important greenhouse gases are carbon dioxide (CO\textsubscript{2}) methane (CH\textsubscript{4}) nitrous oxide (N\textsubscript{2}O). All are mostly produced by human activities. A study conducted by a research team at University of Oxford in England verified that. The study shows that human activities, for example, burning coal, oil and gas, and cutting down forests are largely responsible for increasing greenhouse gases.

28. Which action is not helpful to slow down global warming?

a. Encouraging carpooling
b. Buying high efficiency appliances
c. Recycling
d. Cleaning up your environment

Fact 29

Global warming is also to be the most dangerous threat to the future of wildlife. Plant and Animal Scientists in University of Laval in France recently concluded that within the next 50 years, as many as one-third of all wildlife species in some regions of the world could be headed toward extinction due to global warming. Plants and animals around the world are in real danger of falling victim because their habitat is changing too rapidly for them to keep up.
29. If you cannot catch cold water fish any more in an area where you caught them before, what could you do to still catch them?

a. Go to the north to catch them  
b. Go to the south to catch them  
c. Going to areas that are not inhabited by human  
d. None of above  

Fact 30

Climate change may directly affect human health through increases of the chance of extreme heat waves as well as increases in average temperature. According to research conducted by University of Chicago, temperature increases may lead to more extreme heat waves during the summer. Heat waves are rare events that vary in character and impact. However, they could become more frequent, intense and longer with climate change. Extreme heat increases humans’ body metabolism and temperature that uses up energy and magnify need for oxygen. According to the research team in Seoul National University in South Korea, global warming induced increases in the frequency of smog events and particular air pollution. Sunlight and high temperatures can cause ground-level ozone to increase. The increase of ground-level ozone is especially harmful for those with asthma and other chronic lung diseases. Ozone is a severe irritant that can cause choking, coughing and stinging eyes. It damages lung tissue, aggravates respiratory disease and makes people more susceptible to respiratory infections.

30. Which one of the following is not increased when it is much hotter than normal?

a. Number of visitors to ER  
b. Death rate  
c. Number of asthma attacks  
d. Number of new cases of diabetes
Recall Questions

The article you read described research on global warming being conducted at several universities. Please write down as many of these universities as you can.

________________________________

________________________________

________________________________

________________________________

________________________________

________________________________

________________________________
Appendix G

INFROMED CONSENT FORM
(IRB Approval # 2010111351 EX)

Identification of Project:
Effects of Background Context and Signaling on Reading Comprehension and Recall: The Perspective of Cognitive Load Theory

Purpose of the Research:
This is a research project that will investigate the effect of context and signaling on reading comprehension, recall and cognitive load. You must be 19 years of age or older to participate. You are invited to participate in this study because you are a student in EDPS362 or EDPS457 at the University of Nebraska – Lincoln.

Procedures:
This study will take place in a computer lab. Participation in this study will require approximately 60 minutes of your time. First, you will be asked to complete a demographic checklist and prior knowledge checklist. The demographic checklist consists of four questions and the prior knowledge checklist consists of seven questions about global warming knowledge and belief, and eight questions about self-efficacy in American and Korean geography. Next, you will be randomly assigned to one of the four groups and in each group you will be requested to read one of the four versions of global warming text that contains four segments. At the end of each segment, you will be asked to report your level of interest, motivation, difficulty and investment of mental effort. Once you finish reading the all four segments, you will be asked to report your level of interest, motivation, difficulty and investment of mental effort one more time and complete comprehension and recall test.

Risks and/or Discomforts:
There are no known risks or discomforts related to this research.

Benefits: All students enrolled in Educational Psychology 362 and 457 have a 3-hour research requirement. The participants will receive a 1- hour research requirement for your participation in this study. For students who do not participate in this study, their 1- hour research requirement will be fulfilled by alternative activities such as reviewing research articles/ scholarly publications or completing other research related activities offered by individual instructors.
The information obtained from this study may help us to better understand the effect of context and signaling on reading comprehension, recall, and cognitive load.

Confidentiality:
All the data gathered during this study will be kept strictly confidential. The data will be stored on a computer and can be accessed only by the investigator. The results of this study may be published or presented at scientific meetings but the data will be reported as aggregated data.
Compensation:
As regular course requirement of EDPS362 and EDPS457, you will need to complete a 3-hour research requirement. You will receive a 1-hour research requirement for your participation in this study.

Opportunity to Ask Questions:
You may ask any questions concerning the research either before agreeing to participate or during the research study. Or you may call the investigator at any time, personal phone, (334) 671-8477. If you have any questions that have not been answered by the investigators about your rights as a part of this research, you may contact the University of Nebraska-Lincoln Institutional Review Board, telephone (402) 472-6965.

Freedom to Withdraw:
You are free to decide not to participate or to withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln. Your decision will not result in any loss of benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy:
You are voluntarily making a decision whether or not to participate in this research study. Checking the “accept” box certifies that you have decided to participate and read and understood the information presented. You may print out a copy of this informed consent form to keep.

Name and Phone number of investigator(s)
Minjung Song, M.A., Principal Investigator Office: (402) 472-2223
Roger Bruning, Ph.D., Secondary Investigator Office: (402) 472-2225