VISUALIZING READING COMPREHENSION: UNDERSTANDING THE INFLUENCE OF TEXT STRUCTURES ON READERS’ KNOWLEDGE STRUCTURES

A Dissertation in Learning, Design, and Technology

by

Kyung Kim

© 2017 Kyung Kim
Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

August 2017
The dissertation of Kyung Kim was reviewed and approved* by the following:

Roy B. Clariana
Professor of Education
Dissertation Advisor
Chair of Committee

Simon Hooper
Professor of Education

Priya Sharma
Associate Professor of Education

Ping Li
Professor of Psychology

Susan Land
Director of Graduate Studies, Department of Learning Performance and Systems

*Signatures are on file in the Graduate School
ABSTRACT

My intention is to further validate and extend the application of “knowledge structure (KS)” analysis methods beyond monolingual into bilingual reading settings. This investigation applies KS analysis methods to describe the influence of narrative and expository lesson texts on bilingual readers’ KS. Monolingual native language (L1) reading studies have established that text type, or genre, strongly influences reading comprehension, and narrative texts are easier to recall and understand than expository texts, indicating that the comprehensibility of the content may differ depending on the genre in which it is presented. Thus, it is important to understand reading comprehension differences that are triggered by different text genres. However, the effects of text genres on reading comprehension have rarely been the focus of target language (L2) reading research, where the few L2 studies have reached different conclusions about their relative difficulty. In addition, I consider the interaction of prior knowledge and text genres in L2 reading contexts. The inconclusive and few reported findings in an L2 reading context may largely be due to methodological difficulty because L2 reading is an extraordinarily complex process dependent upon reader-related and text-related factors that are far more varied than those implicated in L1 reading.

For this methodological problem, this investigation proposes a “KS analysis model” to better understand the interactions between pre-reading KS and text genre and between text genre and post-reading KS. An additional aim of this study is to assess how language proficiency modulates the interactions. For that, university mixed proficiency Korean English language learners (n = 616) were randomly assigned to one of 8 conditions that all involved a pre-reading task in L1 or L2 (as a sorting task), reading a text, then from memory a post-reading task in L1 or L2 (as a summary writing), and finally a comprehension posttest (e.g., sort Korean or English, read English expository or narrative text, write Korean or English, posttest).

All of the participants’ sorting and essay artifacts were converted into Pathfinder Networks (PFnets) that were visually and statistically compared with each lesson text’s PFnet they read. For the PFnet analysis, this investigation employed two distinctly different ‘graph theoretic’ metrics,
“Similarity of PFnet” and “Centrality of PFnet”, in order to analyze the PFnets statistically and to visually describe the interactions between text genre and pre- and post-reading KS by proficiency level. The results from the similarity and centrality of PFnets showed that the low proficiency participants’ comprehension of the same text content was greater in the L1 task language and in the narrative text, while the high proficiency participants’ comprehension did not differ as functions of task language and text genre. With respect to prior knowledge interaction, both low and high proficiency participants maintained their pre-reading KS more for the expository text than the narrative text. These findings from the current study can have practical implications for their L2 reading instruction. Narrative texts would be more beneficial to L2 readers who do have lower L2 proficiency because of its superior comprehensibility, while expository texts would be more beneficial to L2 readers who have enough prior knowledge of to-be-learned content because of its tendency to integrate content with prior knowledge.
TABLE OF CONTENTS

List of Figures .................................................................................................................. viii
List of Tables ..................................................................................................................... ix
Acknowledgements ......................................................................................................... x
Chapter 1 .............................................................................................................................. 1
1.1. Background .............................................................................................................. 1
  1.1.1 Reading comprehension and text genre .......................................................... 1
  1.1.2 Knowledge structure in reading ........................................................................ 3
1.2 Purpose of this study ................................................................................................. 5
1.3 Summary of research questions .............................................................................. 6
1.4 Potential significance of this study .......................................................................... 6
1.5 Definition of terms ................................................................................................. 7
1.6 Overview of the chapters ...................................................................................... 8
Chapter 2 ............................................................................................................................ 10
LITERATURE REVIEW .................................................................................................... 10
  2.1 Reading comprehension ........................................................................................ 10
  2.2 Text genre ............................................................................................................. 13
    2.2.1 Narrative and expository genres .................................................................... 13
    2.2.2 Text genre and L1 reading ............................................................................. 14
    2.2.3 Text genre and L2 reading ............................................................................. 16
    2.2.4 Summary ........................................................................................................ 19
  2.3 Knowledge structure ............................................................................................. 20
    2.3.1 Eliciting knowledge structure ........................................................................ 22
    2.3.1.1 Essays (Summary writing) ........................................................................ 22
    2.3.1.2 Concept maps ............................................................................................ 23
    2.3.2 Representing knowledge structure .................................................................. 25
      2.3.2.1 Sorting task converted to Pathfinder Network ...................................... 26
      2.3.2.2 Essay converted to Pathfinder Network ................................................. 28
    2.3.3 Comparing knowledge structure ...................................................................... 30
      2.3.3.1 Similarity of PFnets ................................................................................ 30
      2.3.3.2 Centrality of PFnets .............................................................................. 31
    2.3.4 Summary ......................................................................................................... 35
  2.4 Conclusion .............................................................................................................. 36
Chapter 3 ............................................................................................................................ 37
METHODOLOGY .............................................................................................................. 37
5.2 Research Question 1: The relation between pre-reading KS and text genre ............75
  5.2.1 Low proficiency readers ........................................................................75
  5.2.2 High proficiency readers ........................................................................78

5.3 Research Question 2: The relation between text genre and post-reading KS ........80
  5.3.1 Low proficiency readers ........................................................................81
  5.3.2 High proficiency readers ........................................................................83

5.4 Research Question 3: The validity of this KS measure ....................................87
  5.4.1 Low proficiency readers ........................................................................88
  5.4.2 High proficiency readers ........................................................................90

5.5 Implications ....................................................................................................88
  5.5.1 Low proficiency readers ........................................................................88
  5.5.2 High proficiency readers ........................................................................90

5.6 Limitations .....................................................................................................91

5.5 Future research .............................................................................................92

5.5 Conclusion ......................................................................................................93

Reference ............................................................................................................95

APPENDIX A. Consent Form ..............................................................................103
APPENDIX B. Sorting Task ...............................................................................105
APPENDIX C. Heart Circulatory System .............................................................106
APPENDIX D. Math Task ..................................................................................108
APPENDIX E. Essay Task ..................................................................................110
APPENDIX F. Circulatory System Knowledge Test ..........................................111
APPENDIX G. IRB Approval ..............................................................................112
LIST OF FIGURES

Figure 1. Example of lexical representation of L1 and L2 based on the age of acquisition (Zhao & Li, 2010) ................................................................. 11

Figure 2. The dash link violates triangle equality so the link will not be linked in a PFnet. ... 25

Figure 3. Examples of a fully connected PFnet with 17 concepts and the reduced PFnet .... 26

Figure 4. Example of a sorting task, distance array for the sorting task from Jrate, and its PFnet from KNOT ................................................................. 27

Figure 5. GIKS screen shot of PFnet from a lesson text, and a student’s summary essay .... 29

Figure 6. Graph centrality calculated for four concept map forms (Clariana, Draper, & Land, 2011) ......................................................................................... 32

Figure 7. The proxscal 2-dimensional representation of the map node centrality data (Kim & Clariana, 2015) ........................................................................................................ 34

Figure 8. The research design ................................................................................. 38

Figure 9. Example of a student’s English and Korean sorting map, distance array from Jrate, and PFnet from KNOT ................................................................. 39

Figure 10. The two-way interaction of similarity to the expert before and after reading for low proficiency and high proficiency participants ........................................................................ 42

Figure 11. KS group convergence by proficiency level ........................................................ 45

Figure 12. Group average graph centrality of the low proficiency and high proficiency participants ........................................................................................................ 47

Figure 13. The proxscal 2-dimensional representation of the pre-to-post sorting task node centrality data................................................................................ 48

Figure 14. Research design diagram ............................................................................. 56

Figure 15. The comprehension posttest two-way interaction of essay language and text genre for both low proficiency and high proficiency .................................................................. 65

Figure 16. Graph centrality of the low proficient and high proficient participants .............. 68

Figure 17. Group-level proxscal 2-dimensional representation of the PFnet node centrality data of the narrative text and expository text from pre-to-post for the eight treatment conditions ................................................................................ 71
# LIST OF TABLES

Table 1. Example of node and graph degree centrality (Clariana, Draper, & Land, 2011) ....35

Table 2. Average posttest score of all groups, PFnet similarity Fisher z means to the expert as *Expert*, and to the individual Posttest as *Posttest* ..........................................................41

Table 3. Within student raw proximity pre-to-post sorting task Fisher z means and standard deviations for each treatment in both high proficient and low proficient groups .....43

Table 4. Within condition KS convergence as average percent overlap for the low and high proficiency groups ........................................................................................................44

Table 5. Within-student pre-to-post PFnet percent overlap and standard deviations with Cohen’s effect size *d* for each treatment in both high proficiency and low proficiency groups ........................................................................................................58

Table 6. Pairwise comparisons between the eight treatment means at each proficiency level, ordered from greatest to least. ........................................................................................................59

Table 7. Within-student lesson texts-to-essays PFnet percent overlap and standard deviations with Cohen’s effect size *d* for each treatment in both high proficiency and low proficiency groups ........................................................................................................62

Table 8. Pairwise comparisons between the eight treatment means at each proficiency level, ordered from greatest to least. ........................................................................................................62

Table 9. Means and standard deviations for comprehension posttest scores, essay PFnet similarity to the lesson text as *Sim to Text* and to the individual Posttest as *Sim to Posttest*, and Graph Centrality (*C_\text{graph}* a measure of KS form) ........................................64

Table 10. Summary of results above for pre-to-post and text-to-essay PFnet similarity results ........................................................................................................................................67

Table 11. Summary of the results ........................................................................................................................................73
ACKNOWLEDGEMENTS

I would like to express my deep gratitude to my advisor, Dr. Roy B. Clariana, who has been there along this incredible journey with me, and provide all the help and support he can. It was a pleasure working with Dr. Roy, and this dissertation would not have been completed in its current form without him. Dr. Roy, you are my academic father. I truly believe I still have so many to learn from, and share with you academically, and in life in the future.

I dedicate this dissertation to my wife (SooYeon), first son (YunSeong), second son (JaeSeong), and my daughter (Ain), for they inspired me to not only finish the journey, but also constitute the fuel to continue the work. To my beloved wife, SooYeon. Your love, trust, and support in every little step I made in this journey made me a stronger and better person. I can’t express how grateful I am to have you as my wife. I am glad we took this journey together. Thank you for your being there! To my kids, YunSeong, JaeSeong, and Ain Kim. I love you very much, and thank you for being an important part of this journey. You motivate me to pursue my dreams and I hope I inspire you to pursue yours!
Chapter 1
INTRODUCTION

1.1. Background

The U.S. Census Bureau’s American Community Survey (Ryan, 2013) reported that the number of people who speak a language other than English at home is 61.8 million, up 2.2 million since 2010. One in five U.S. residents now speaks a foreign language at home (as their native language), so English is the target language (i.e., a language other than one’s native language that is being learned) of multiple millions of individuals both in the U.S. and around the world. What instructional design advice is there for these students in our classrooms who must learn in English? This investigation focuses on reading for the target language learners because of the reality that success in school and even in adulthood depends largely on the ability to comprehend written information. Accordingly, there have been several research-based efforts to help target language reading comprehension (see for review, Karim, 2010), but the influence of text genre in a target language reading is not well understood. Thus, it is important to consider where and how the text genre influences individual target language readers’ understanding of the text in any way.

1.1.1 Reading comprehension and text genre

My theoretical framework for reading comprehension is aligned with Kintsch’s (1988) discourse comprehension model, that proposes that good readers attempt to construct mental representations not only of the text content itself (textbase), but also of the situation being described in the text (i.e., the “situation model” of van Dijk & Kintsch, 1983; or the “mental model” of Johnson-Laird, 1983) by integrating the textbase with their related background knowledge. Perfetti (1989) defined the textbase as the author’s intended text meaning while the situation model is the reader’s interpretation of the text, i.e., a personal mental representation of what a text is about. The situation
model a reader constructs depends very much on the reader’s relevant prior knowledge, experience, interests, goals, language competency, and so on because these will tend to filter what is remembered from the text. Thus, it is quite possible for readers to construct an adequate textbase but fail to link it with their background knowledge; the texts are remembered but not understood (Kintsch, 1991).

This situation model, represented as the person-specific interpretation of the text, carries out the function of an internal context for language use (e.g., for writing, speaking, tests, etc.) and this context undoubtedly exerts varied effects on performance such as oral and written production tasks (Sawaki, Quinlan, & Lee, 2013). Thus, the construction of well-integrated situation models is an indicator of and key to successful reading comprehension, and should therefore be a major goal for readers (e.g., Glenberg, Krueley, & Langston, 1994; van Dijk et al., 1983; Zwaan, Magliano, & Graesser, 1995; Zwann & Radvansky, 1998).

When applied in a second language setting, the perspective on reading comprehension as ‘situation model-building’ begs several important theoretical questions: What is the first language situation model? What is the second or target language situation model? And are these the same or different? Given that language influences the construction of a situation model (e.g., Barry & Lazarte, 2000), I propose that a situational representation established by a bilingual reader in one language may or may not bring about a similar situational representation in the other language. A pilot study #1 (Kim, 2017) that is explained in more detail in section 3.1 addresses these issues using the same ‘knowledge structure’ analysis approach used in the present investigation. This current investigation extends that pilot study.

Native language (L1) reading research has demonstrated that text genre is an important predictor of reading comprehension (Graesser, Hauft-Smith, Cohen & Pyles, 1980; Kintsch & Young, 1984; Petros, Norgaard, Olson, & Tabor, 1989; Zabrucky & Ratner, 1992). The bulk of L1 reading studies have provided ample evidence that narrative, or story-based, texts are easier to recall and understand than expository, or informational, texts (Graesser et al., 1980; Grasesser, Golding, & Long, 1984; Kintsch et al., 1984; Luszcz, 1993; Norgaard et al., 1989; Tun, 1989; Wolfe, 2005; Zabrucky et al., 1992).
Given that the majority of the L1 reading research reports narratives’ superior comprehensibility in L1 reading contexts, it would be expected that similar findings would be observable in target language (L2) reading research. However, very few studies comparing the influence of the narrative and expository text genres on L2 reading comprehension have been conducted with L2 readers (Baretta, Tomitch, MacNair, Lim, & Waldie, 2009; Bensoussan, 1990; Bullock & Lantolf, 1987), and the few extant L2 studies have reached different conclusions about the text genre’s relative difficulty. These few and inconclusive findings in an L2 context may largely be due to methodological difficulty because L2 reading is an extraordinarily complex, multidimensional process involving both reader-related and text-related factors that are far more varied than in L1 reading. Thus, it is unclear whether there is an overall advantage in delivering content in a narrative or expository format in an L2 context. A pilot study #2 (Clariana, Wolfe, & Kim, 2014) conducted in an L1 reading context demonstrated that ‘knowledge structure’ measures can differentiate between undergraduate monolingual participants’ memories of narrative and expository lesson text. Using the same knowledge structure measures, this current investigation positions the likely effects of text genre within L2 reading.

1.1.2 Knowledge structure in reading

Knowledge structure (KS) reflects the organization and interrelationships of knowledge in memory (Jonassen, Beissner, & Yacci, 1993) that has been shown to correlate with reading comprehension, for example, in monolingual settings with English (Clariana, Wolfe, & Kim, 2014), Dutch (Fesel, Segers, Clariana, & Verhoeven, 2015), and Chinese (Su & Hung, 2010), and also in bilingual settings with Dutch-English (Mun, 2015) and Korean-English (Kim & Clariana, 2015), and Chinese-English (Tang & Clariana, 2016).

Cognitive psychologists have been interested in KS as a way to understand the nature and manner in which knowledge is represented in human cognition. Rather than only focusing on the text content itself, they are interested in how the reader derives an internal mental representation based on
his or her interpretation of the text. In particular, cognitive psychologists view KS as a person-specific phenomenon, where reading allows the person to build an individualized situation model (Crossley & McNamara, 2009). Situation models are constantly updated in terms of the relations of propositions, as reading unfolds and as comprehension is achieved. Viewed this way, KS is not a static, fixed property of the text, but is a dynamic, person-specific knowledge, dependent upon the reader’s prior experience/background. Spector and Koszalka (2004) argued that one may view learning progress as cognitive changes in the “direction” towards expert-like KS. In this sense, reading progress is likely to be well-illustrated by the notion of KS when reading progress is characterized as a set of “directional” changes in a reader’s KS (Schlomske & Pirnay-Dummer, 2009).

Indeed, several studies have demonstrated that measures of KS can be used to differentiate between good readers and poor readers (e.g., Schvaneveldt, 1985), predict classroom reading and achievement (e.g., Goldsmith, Johnson, & Acton, 1991), evaluate students’ reading comprehension (e.g., Clariana, Wallace, & Godshalk, 2009), describe cognitive state changes after reading (e.g., Clariana, Engelmann, & Yu, 2013), reveal KS transfer from L1 to L2 in reading (Kim et al., 2015), and recently to propose neural mechanisms underlying reading comprehension (Li & Clariana, 2017).

Then how can we effectively capture and visually represent the dynamic structure of KS in this cognitive perspective of reading? Previous research has used a variety of methods to study situation models as KS (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; McMaster et al., 2012; Reyna & Brainerd, 1995). Second language researches are adopting cognitive studies which emphasize KS as associative networks of concepts that contain weighted connections (much like a mental lexicon that contains associations between words), and reading allows the strengthening of the connections as well as the enrichment of concepts to occur in the network. For example, Zareva and Wolter (2012) note that “…the metaphor that the lexicon is a network, which must be highly organized, has started to dominate lexical research and has given rise to studies comparing the features of L1 users’ and L2 users’ associative connections across a range of L1 and subsequently learnt L2.” (p.42). Thus, methods that can capture network properties are useful for representing and describing KS.
Following this connectionist theoretical bias, this present investigation endeavors to convert texts into network graphs, which are hypothesized to represent the most salient KS reflected in the text, for visually describing the influence of narrative and expository lesson texts’ KS on reader’s KS reflected in their recall essays. My working assumption is that readers’ representations of the narrative and expository lesson texts will be differentiable by the network structure of their free recall essays, as evidenced by the pilot study #2 (Clariana et al., 2014) that was conducted in an L1 reading context.

1.2 Purpose of this study

A central issue in reading comprehension research is the question of how to deliver content to readers so that they can process it in a meaningful way. Since reading involves an interaction between a reader and a text, logically, features of the text that readers read would play a very important role in reading comprehension (i.e., text signals, Kim & Clariana, 2016). At a larger scale, L1 reading studies have demonstrated that text genre influences the processing and organization of text information, and narrative texts are easier to recall and understand than expository text, indicating that the comprehensibility of the content may differ depending on the genre in which it is presented. Thus, it is important to understand reading processing differences that are triggered by the different text genres.

However, as explained above, the effects of the text genre on reading comprehension have rarely been the focus of L2 reading research. The few L2 studies that have examined this issue have reached different conclusions perhaps because of the methodological difficulty in controlling various factors in an L2 reading. This present investigation applies KS analysis and tools, used in several pilot L2 reading studies (Clariana et al., 2014; Kim & Clariana, 2015, 2016, 2017), to try to better understand the influence of narrative and expository lesson texts on readers’ KS in L2 reading. In addition, this investigation examines L2 readers’ prior knowledge as potential mediators of genre effects. Thus, the purposes of this investigation are to appraise the relationships (1) between pre-reading KS and text genre, and (2) between text genre and post-reading KS, and so (3) estimate the
capability of KS measure to describe the expected relationships between the text genre and reader’s pre- and post-reading KS.

1.3 Summary of research questions

The research questions posed by this investigation relate to the relationships between readers’ pre-reading KS and text genre (Question 1), between text genre and post-reading KS (Question 2), and the capability of KS analysis to address these questions (Question 3).

- Question 1: Is prior knowledge differently utilized when processing these different text genre (narrative and expository) as evidenced in the network structures of the post-reading essay task? If so, how does language proficiency modulate the difference?
- Question 2: Is there difference in L2 reading comprehension due to text genre, as evidenced in L1 reading research? If so, how does language proficiency modulate the difference?
- Question 3: Is the KS analysis effective and appropriate to describe the relationships between text genre and readers’ pre- and post-reading KS?

1.4 Potential significance of this study

The findings of this investigation are expected to contribute to L2 reading research and instruction in several ways. First, this investigation seeks to fill the gap in existing L2 text genre research, which has not examined the relative reading differences between narrative and expository texts for L2 readers at different L2 proficient levels, or the contribution of these text genres to their L2 reading comprehension. Thus, results related to reading processing of each genre could have implications for L2 reading curriculum design, including identifying the genres of texts that can be most beneficial at low or high L2 proficiency levels, and identifying the level of instructional support required for each text genre.
Second, this investigation seeks to understand the relationship between readers’ prior knowledge as KS and text genres. Thus, results related to the possible interaction between prior knowledge and L2 text genre could have implications for an instruction, and lead to pedagogical interventions to help less successful L2 reader and to identify L2 readers who may benefit from such interventions.

Third, this investigation employs KS analysis methods to address the research questions above. Most previous studies in both L1 and L2 reading fields have not conceptualized KS as this investigation does. This investigation, thus, present a novel approach to measure readers’ mental representation of reading comprehension as KS. I believe that L2 reading studies along this KS line can open up a new avenue whereby L2 reading processing can be scrutinized in a more in-depth manner, thus informing and enriching the KS approach to reading research in an L2 as well as L1.

1.5 Definition of terms

*Narrative* refers to genre of text broadly defined as “story”. Narrative texts typically contain characters, episodes or sequences of events, temporal and spatial placements of events, and temporal or causal relationships between events. Affective engagement of the reader is one of the principal communicative intents of narrative texts.

*Expository* refers to informational texts. Expository texts typically convey information in a static, usually non-chronological manner. The primary communicative purpose of expository texts is to inform.

*Knowledge structure*, also known as *cognitive structure* or *structural knowledge* (Jonassen et al., 1993), refers to the manner in which an individual organizes the relationships between concepts in memory (Clariana, 2009). Hence, an individual knowledge structure is made up of the interrelationships between concepts or facts and procedural elements (Ifenthaler, 2011; Ifenthaler, Masduki, & Seel, 2011). The National Research Council report (NRC, 2001) recommended that “Assessment should evaluate what schemas an individual has…” and that “…evaluation should
include how a person organizes acquired information…” (p. 102).

**Textbase** refers to a somewhat linear “verbatim” encoding of a text’s structure of propositions (i.e., sentences, Kintsch, 1988, 1998, 2005. Note: English sentences are typically noun-verb-noun while Korean are noun-noun-verb). A text, at this level, becomes a network of interconnected propositions, and the resulting network of propositions is called the *microstructure* of the text. To distinguish this sentence-level structure (microstructure) from a discourse-level structure, the term *macrostructure* is used. The macrostructure represents the global organization of the text in sections and subsections, main points and minor digressions. Microstructure and macrostructure together form the textbase, the semantic underpinning of a text. Thus, fluent readers usually form a textbase that mirrors the author’s intended *meaning* (Perfetti, 1989).

**Situation model** (“mental model” of Johnson-Laird, 1983) refers to a relational “gist” encoding of the text. While the textbase represents the surface meaning and organization of the text, the situation model can go far beyond the text itself. The situation model integrates the new information from a text with what the reader knows by forming implicit links between them. Thus, a reader’s situation model depends very much on the reader’s relevant prior knowledge, experience, interests, goals, language competency, and so on because these will tend to filter what is remembered from the text. So the reader’s situation model, the personal *interpretation* (Perfetti, 1989) of what the text is about, may or may not match the author’s situation model, represented as the textbase.

### 1.6 Overview of the chapters

In Chapter 2, I will review previous research that guided the research questions. To begin, I will discuss studies on reading comprehension and then discuss both L1 and L2 studies that have investigated reading comprehension of both text genres. Next, I will discuss studies on knowledge structure, including eliciting, representing, and comparing knowledge structure.

Chapter 3’s focus is the methodology of the present study. However, because this methodology was adapted from a pilot study, I will begin by describing the pilot study’s research
questions, hypotheses, methodology and results, followed by a discussion of their implication for the main study. Then, I will present the research questions, hypotheses and methodology of the main experiment, including participants, materials, and procedure.

Results of the main experimental study are presented in Chapter 4. I will begin with comprehension posttest data and then present $PFnet$ comparison data including post-reading essay PFnet similarity to the pre-reading $PFnets$ and to the lesson text $PFnets$.

In Chapter 5, I will discuss theoretical, methodological and pedagogical implications of the results before addressing the study’s limitations, exploring possible avenues for future research, and presenting general concluding remarks.
Chapter 2

LITERATURE REVIEW

2.1 Reading comprehension

Readers attempt to construct the textbase of the text content (i.e., a verbatim encoding of the text) and combine the textbase with their related background knowledge to construct a situation model (a gist encoding of the text) to support text comprehension. Perfetti (1989) defined the textbase as the author’s intended text meaning, while the situation model is the reader’s interpretation of the text, the personal KS of what the text is about. That is, the situation model is developed from the interaction between the information provided by the text and further information derived from the reader’s prior knowledge. So the situation model depends very much on the relevant background knowledge residing in the reader’s mind. The textbase and situation model are related but different mental representations of a text (the meaning and the interpretation), and these two could possibly be described using KS approaches.

The situation model, represented as KS of what readers have interpreted from a given text, carries out the function of an internal context for production (i.e., language use) and this context undoubtedly exerts varied effects on performance (Glenberg et al., 1994; Sawaki, et al., 2013; van Dijk et al., 1983; Zwaan et al., 1995; Zwann et al., 1998; Zwann, Radvansky, Hilliard, & Curiel, 1998). Thus, many cognitive psychologists have argued that the construction of coherent situation models is tantamount to the successful comprehension of a text (Glenberg, et al., 1994; van Dijk et al., 1983; Zwaan, et al., 1995; Zwann et al., 1998).

If this situation model account based on L1 reading research is extended to L2 reading research, then, a natural question is how differently or similarly bilingual readers construct their L1 and L2 situation models of the same lesson text. Many cognitive psychologists and psycholinguistics have demonstrated that language performs a function of processing instructions on how to construct a mental representation of the text, rather than as information to analyze syntactically and semantically
and then store in memory (Barry & Lazarte, 2000; Gernsbacher, 1990). Thus, the question of how bilingual readers who are assigned two different processing instructions construct their L1 and L2 situation models of texts is worth investigating, but has not been fully investigated.

Given the strong influence of language on the construction of a situational representation, it would be reasonable to assume that a situation model representation may or may not be the same in L1 and L2. For example, the alternate scientific conception literature (native language) has consistently demonstrated that naïve positions often coexist along with scientific understanding (Sinatra, Kienhues, & Hofer, 2014); for example, a bilingual student may say that “the earth rotates every 24 hours” in the English only science classroom setting but then at home will continue to say “태양이 떠오르다” (e.g., the sun rises). Similarly, artificial neural network models also demonstrate that in an L1-L2 well-structured lexical set, well-structured L2 is clumped but separate from the well-structured L1, appearing like islands in a sea (Zhao & Li, 2010), and so either the L1 or L2 structured sets can engender a situation model based upon the unique structure of each (see Figure 1 for example).

Figure 1. Example of lexical representation of L1 and L2 based on the age of acquisition, generated by DevLex-II model (Developmental Lexicon, L1 et al., 2007). Dark areas correspond to L2 words (adapted image from Zhao et al., 2010). The simultaneous acquisition shows clear distinct lexical territory of the two languages (left), early L2 learning shows similar patterns with the simultaneous learning, although the L2 spaces are smaller compared to the L1 space (middle), and late L2 learning shows no large independent areas for the L2 representation (right).
In other words, alternate potential situation model interpretations of the same phenomena could possible coexist in memory separately as L1 and L2, and can be differently represented depending on the activated language, and this is especially true for high proficient bilinguals who likely have a local well-structured L2; thus high proficient bilinguals could reasonably have two potential situation models, one for each language, but probably only one is actualized, that is the one that is called upon by the task. Whereas low proficient bilinguals would likely have one situation model that is an amalgam of L1 and L2 but mainly is influenced by L1 structure, somewhat regardless of the language of the lesson or of the task that is used to elicit the structure. Note that the Google AI translate system using a Neural Machine Translation model recently demonstrated a common ground between languages whereby sentences with the same meaning are represented in a similar way regardless of language – which they say is an example of an “interlingua” (Johnson et al., 2016).

A pilot study #1 (Kim, 2017) that is explained in more detail in section 3.1 has investigated this assumption by applying KS analysis methods. The pilot data show that high proficient bilingual readers constructed similar situation models of the same L2 text in both L1 and L2 due to their symmetry in L1-L2 processing, while low proficient bilingual readers constructed different situation models depending on the language in which the text is comprehended, probably due to their asymmetry in L1-L2 KS that then differentially influences reading (e.g., Zareva, 2017) (see for more detail section 3.1). This pilot study demonstrated that L2 proficiency significantly contributes to comprehension of L2 text (i.e., L2 situation model construction), supporting prior studies reporting the importance of language proficiency for constructing meaning from text (i.e., textbase) and connecting text meaning with prior knowledge (i.e., situation model). For example, Perfetti and Stafura (2014) consider the readers’ lexical knowledge/proficiency as a prime candidate for predicting successes or failure in reading comprehension.

However, reading also requires an interaction between a reader and a particular text, whose structure and content influence how text information is stored in memory and used and how the readers’ knowledge is deployed (Baker & Wigfield, 1999; Gottfried, 1990; Kintsch, 1998, 2004, & 2005). Though L1 reading research has consistently shown that text type, or genre, is an important
text-based predictor of reading comprehension and provided overwhelming evidence of narratives’ superior comprehensibility in L1 settings, the few L2 studies examining text genres have reached different conclusions about their relatively difficulty. As a follow-up inquiry, thus, the present investigation considers whether there is a difference in L2 text comprehension due to text genres. Given the predictive power of L2 proficiency as evidenced by a pilot study (Kim, 2017) and other prior L2 studies (e.g., Perfetti & Stafura, 2014), another important question is how language proficiency modulates the influence of the interaction. Thus, this present investigation attempts to explore the difference in comprehension of each genre by L2 proficiency level.

In the following section, I will begin by defining narrative and expository texts and discuss past L1 and L2 text genre research examining the relationship between each genre and reading comprehension. Next, I will explain why a “knowledge structure” approach can be appropriate to investigate these research questions.

2.2 Text genre

2.2.1 Narrative and expository genres

Although there is no prevailing consensus on a precise definition of narrative text, a general definition might be that narrative texts are "stories". Graesser et al. (1991) note that whether they relate actual or fictitious events, narratives are composed of story-like elements, such as characters, temporal and spatial placements, and episodes or sequences of events. Larsen (1984) maintains that a recounting of these events is the hallmark of narrative texts. In addition to being situated in a particular place and time, events in narratives typically unfold over some period of time. These chronological events also share causal relationships. For example, narratives usually describe complications or problems that the main character(s) encounter(s), and subsequent events are related to the resolution of the complications. Graesser et al. (1991) also observed that narratives are often intended to arouse affective reactions in the reader. Narratives are typically written to entertain the
reader in some way, and do so by manipulating readers’ emotions such as curiosity, surprise, amusement, or suspense.

Expository texts, on the other hand, are intended to inform. Instead of recounting an episodic story, expository texts use communication strategies such as orientation and clarification to convey information to the reader (Larsen, 1984). Whereas narratives describe events that develop over time, expository texts often communicate information in a static, non-chronological fashion. Unlike narratives, expository texts are usually not intended to engage readers affectively. Though expository texts certainly may elicit affective reactions in some readers, arousing an emotional response is typically not among the author’s primary communicative purposes.

Weaver and Kintsch (1991) thus summarize the differences between the two genres as: “...the main thrust of expository texts is to communicate information so that the reader might learn something. The main focus of a narrative text is to tell a story so that the reader may be entertained.” (p.230). However, they also concede that the distinction between expository and narrative texts is not absolute. Narrative texts such as fables, for example, have a clear didactic purpose. Expository texts such as newspapers and magazine articles may contain some narrative elements (for example, describing an episode or a sequence of events) and may be entertaining as well as informative.

It is also important to note that these two genres represent only a general level of text classification. Within each text genre, a variety of subgenres exist. Novels, short stories and plays can all be categorized as narratives, for example, while the expository genre includes texts such as essays, news reports, or journal articles.

2.2.2 Text genre and L1 reading

L1 studies have overwhelmingly shown that narratives are easier to comprehend and recall than expository texts. These results have been consistent for both child and adult readers. Zabrucky and Ratner’s (1992) study of 6th grade children found that students recalled significantly more from reading narrative texts than expository texts. The researchers further observed that reading expository
passages required significantly more effort, as measured by “lookbacks” or re-readings of portions of the text, and longer reading times than the narrative passages. In two studies with college students (Kintsch et al., 1984; Kozminsky, 1977), participants read one narrative and two types of expository texts, a description and a report. Students recalled significantly more from the narrative texts (on average, 30-33% of all text propositions) than either the descriptions (20-26%) or the reports (12-20%). Graesser et al. (1980) also found significant differences between narrative and expository text comprehension by college students using a recall measure, 62% of narrative propositions were recalled, compared to only 37% of expository propositions.

Superior outcomes for narrative texts have also been observed in studies comparing reading comprehension between groups of young adults and senior citizens. Tun (1989) found that both college students and older adults (aged 65-80) comprehended significantly more from narrative texts as assessed by both a recall measure and a multiple-choice test. Young adults recalled 51% of propositions from narrative texts and scored 92% on the narrative multiple-choice test, compared to 41% recall and 88% multiple-choice scores for expository texts. Older participants recalled 31% of narrative propositions and answered 93% of multiple-choice questions correctly; their expository comprehension scores were 19% for recall and 73% for multiple choice. Petros, Norgaard, Olson, and Tabor (1989) reported a similar trend in a study where texts of each genre were presented orally instead of in writing. Both young adults and seniors recalled significantly more propositions from narrative texts (72% and 60%, respectively) than from expository texts (57% and 39%).

Some of the unique features that distinguish narratives from expository texts also seem to explain their superior comprehensibility. As described in section 2.1.1, narratives are characterized by both temporal and causal cohesiveness. Certain theorists propose that this type of coherence facilitates the creation of a mental representation of the text, the retrieval of related prior knowledge from memory, and the integration of this information into the mental text representation. Kintsch and Young (1984) maintain that narrative text structures promote situation model construction, and therefore comprehension and memory of the text, because of their cohesiveness. The salient temporal and causal cues contained in narratives help readers to efficiently retrieve both textual information and
prior knowledge from memory and to integrate it into their situation model of the text. That is, the unique cohesiveness feature of narrative text genre could trigger readers to place relatively greater emphasis on integration of text content with prior knowledge than expository, which might lead to better reading comprehension (see for more examples, Kuhara-Kojima & Hatano, 1991; Schneider, Korkel, & Weinert, 1989; Spilich, Vesonder, Chiesi, & Voss, 1979).

The familiarity of narrative structure also appears to play an important role in comprehension of this genre. Koda (2005) notes that some training may be required to recognize the structure of exposition and argumentation, while narrative story structures are familiar even to young children who cannot yet read or write. Graesser et al. (1991) propose that the event sequences that comprise narrative texts are so familiar to us because they also characterize our personal, everyday experiences. Thus, this may generalize to narratives in other languages.

### 2.2.3 Text genre and L2 reading

Given the overwhelming evidence of narratives' superior comprehensibility in L1 settings, it would be expected that similar results would be obtained in L2 contexts. However, very little research examining the relationship of the narrative and expository genres to memory and comprehension of the L2 text has been conducted with L2 learners, and the few L2 studies have reached divergent conclusions.

Bullock and Lantolf (1987) used a narrative short story and an expository text on insects to compare English native and English language learners (ELLs) performance on cloze tests for each genre. Although one group of ELLs, participants taking a year-long advanced English class to prepare them for graduate school (n=9), scored much higher on the narrative cloze test (75%) than on the expository test (51%), another group of ELL graduate students (n=11) had virtually identical scores on both measures (narrative 97%, expository 94%; maybe due to a ceiling effect).

In Bensoussan's (1990) study, translation of L2 texts into the L1 was used to measure reading comprehension of narrative and expository texts. Advanced university ELLs (n=105) read an
expository text in English about paranoia and then translated it into Hebrew, their native language. A separate group of advanced ELLs (n=60) read a narrative excerpt from an F. Scott Fitzgerald story in English and translated it into their native language, Hebrew. The researcher analyzed each text according to discourse aspects including both local (word and sentence-level) and global level structures (units of meaning involving more than one sentence); these analyses were then compared to the participants' translations. Bensoussan found significantly higher mistranslation rates for the narrative than the expository text (335 and 190 mistranslations, respectively) across nearly all discourse categories. The narrative text translations included more mistranslations of prepositional content, vocabulary and expressions, pronoun agreement and communicative function (e.g., translating what was a neutral statement by the author as a positive or negative statement; maybe due to a strong interaction with individual background knowledge). The only discourse category that proved more problematic for expository texts was the local-level feature of grammatical cohesion, or the translation of linking and transition words that connected ideas (e.g., moreover, therefore, because). These mistranslations suggest strong situation models in the narrative condition.

In contrast with these findings but consistent with L1 research, DuBravac and Dalle (2002) found greater miscomprehension of expository texts. The researchers used student-generated questions to assess comprehension. Intermediate-level English L1-French L2 students (n=47) read one of two narratives and one of two expository texts. Expository texts were taken from French daily newspapers, and narrative texts were excerpted from contemporary literary works. Each text was divided into five sections; upon reaching the end of each section, participants were instructed to formulate a question whose goal was to assess how well another person reading the text would have understood that section. The number of questions indicating that the students had misunderstood parts the text was significantly higher for expository texts: 24%, compared to a 6% miscomprehension rate for narrative texts.

These incompatible findings might be largely due to methodological difficulty in controlling reader-related (e.g., L2 proficiency difference) and/or text-related factors (e.g., text difference). First, both studies were likely affected by differences between the two texts. The researchers of the two
studies did not make attempts to control for topic familiarity, difficulty, and complexity of grammar and vocabulary between the narrative and expository texts because it is difficult to create two equivalent texts in each format. Bensoussan (1990) also noted this problem in her study, the texts representing each genre were not necessarily equivalent. When content and genre are confounded, however, it may be not possible to draw precise conclusions about the influence of genre on the text comprehension.

Second, the difference in tasks (translation versus question formation) may also have accounted for differences in results. Although Bensoussan (1990) explained that translation “is closely linked to the reading process; only those text elements that have been read and comprehended can be adequately translated” (p.51), it can also be argued that reading and translation are two distinct skills. Indeed, the author concedes that the translation task itself may have been the source of some errors. DuBravac and Dalle’s (2002) question formation task also has weaknesses. The authors acknowledge that participants were not required to supply the answers to questions they had formulated, so it could not be verified that the questions they generated demonstrated that they had indeed understood the text.

Third, perhaps most critically, these L2 genre studies also limited their investigation to one level of learner, either intermediate (DuBravac et al., 2002) or advanced (Bensoussan, 1990; Bullock et al., 1987). Other reading research, however, suggests that learners’ level of language proficiency may determine how well they are able to exploit the features of different text structures. Horiba (1990), for example, found differential effects of proficiency level on the amount of attention paid to local and global text features. A think-aloud protocol was used to compare the mental reading processes between these proficiency groups. After reading each sentence of a narrative story, participants (9 native Japanese speakers, 11 nonnative advanced Japanese speakers) reported what they were thinking about when reading. Quantitative and qualitative analyses of their comments revealed that nonnative speakers attended significantly more to local (word and sentence-level) text features, whereas native speakers concentrated on global text comprehension. Nonnative speakers frequently made comments about their efforts to decode words and phrases, whereas native speakers
made no comments about the linguistic features of the text. Instead, native speakers commented significantly more about making inferences and connecting the text to their general knowledge (e.g., personal interpretations). Chen and Donin (1997) reported similar results in a study of Chinese ELLs (n=36). The researchers considered the amount of time taken to read each of two expository texts in English, as longer reading times are associated with additional mental effort required to decode words and sentences. Learners at low-intermediate and intermediate levels spent significantly more time attending to these local-level text features than high-intermediate and high proficiency learners. These results suggest that lower-level proficiency readers may be less able to take advantage of genre-level text cues that facilitate comprehension, such as the salient temporal and causal relationships between events in narrative texts.

2.2.4 Summary

Narrative texts often entertain readers and play on a wide spectrum of their emotions. Narratives also appear to engage readers cognitively in different ways than other genres. The cohesiveness and natural familiarity inherent to the narrative genre provide cues that facilitate the mental construction of text meaning (i.e., easy for textbase construction), the retrieval of related prior knowledge from memory (i.e., easy for integration with prior knowledge), and the integration of this knowledge into the representation of the text's meaning (i.e., easy for situation model construction). L1 studies have provided a wealth of evidence supporting the facilitating role of the narrative genre in memory and reading comprehension. However, these results have not yet been replicated in L2 settings, where the few studies examining narrative and expository text comprehension have mixed results. The lack of consistency in results as well as methodology in these studies justifies further investigation of the relationship between text genre and L2 reading comprehension. In addition, it is important to examine the contribution of L2 proficiency level, as there is some evidence of the existence of language proficiency threshold below which readers may not effectively take advantage
of genre cues. Furthermore, the relationship between text genre and prior knowledge in L2 context has not been thoroughly investigated in L2 settings.

2.3 Knowledge structure

Theoretically based on schema theory, semantic networks, and spreading activation theory, knowledge structure (KS) refers to how information elements are organized, in people and in artifacts (Clariana, 2010). It is becoming widely understood that meaningful knowledge leads to well-organized knowledge (e.g., novice-to-expert, Herr, 2008). For example, the National Research Council (NRC; Bransford, Brown, & Cocking, 2000) recommends that “Assessments should evaluate what schemas an individual has…” and that “This evaluation should include how a person organizes acquired information…” (p. 102). Learning and attaining new knowledge is mainly dependent on how we organize the knowledge in our memory (Clariana, 2010).

Consequently, KS has been recognized as an important part of cognitive processing – affecting learners’ ability to recall and comprehend what they have learned, and further to transfer what they know to new problems and settings (Clariana et al., 2009; Clariana et al., 2013; Goldsmith et al., 1991; Kim et al., 2014; Schvaneveldt, 1985). KS is cognitive structure or structural knowledge, the pattern of relationships among concepts in memory. In this view, explicit KS externally elicited is a snapshot of the degree to which learners have organized and comprehended the content of a specific context. Clariana (2010) proposed that KS is pre-propositional, but it is the precursor of meaningful expression and thus the underpinning of thought. Due to our dimensionally limited senses, knowledge elements usually enter memory as sequential (linear) strings of propositions (i.e., when reading and listening), but these linear strings, after consolidation with existing traces, can have more complex relational patterns. This present investigation follows the perspective that KS is both linear and relational at the same time.

In relation to reading, reading has been characterized as an interactive process between a reader and a text. Following a pilot study #2 (Clariana et al., 2014), my working assumption is that the
author’s high-dimensional (relational) KS (i.e., author’s situation model) must be converted to lower dimensional sequential (linear) expository text form, and then the reader reconstitutes the low-dimensional information back into their own higher dimensional KS (reader’s situation model). In this perspective, the readers’ situation model may or may not match the author’s situation model reflected in the expository text, but the reader’s ability to form a coherent situation model that the author’s intended is an indicator of successful expository reading comprehension (Fesel, Segers, Verhoeven, & Clariana, 2015; Kintsch, 1998; Zwaan et al., 1995), and should therefore be a major goal for any competent reader.

Then, the natural question is how one measures whether a student has been able to build such structure after reading a text. Recent cognitive studies emphasize KS as associative networks of concepts with weighted connections (i.e., a mental lexicon that consists of weighted associations between words), and reading can facilitate the strengthening of link weight as well as the enrichment of the concepts in the mental network (Meyer, Ray, & Middlemiss, 2012). Clariana (Clariana, Engelmann, & Yu, 2013; Clariana et al., 2014) argued that learning outcomes should be examined with the framework of a nomological network in which the interrelationships among constructs are identified and empirically tested, and thus methods that can capture network properties can be the most effective for representing and describing the KS. Based on a connectionist theoretical bias, a modified concept map technique can be a way to visualize a structure of an individual learner’s knowledge, or KS.

This present investigation followed a fairly standard three-phase concept map technique (Curtis & Davis, 2013; Jonassen et al., 1993; Kim, 2012): (1) Knowledge elicitation, (2) knowledge representation, and (3) knowledge comparison. Following is a description of each of these three phases.
2.3.1 Eliciting knowledge structure

How can we elicit KS? Jonassen et al. (1993) described a number of approaches for representing KS. Of these, concept maps and essays may be an appropriate approach for eliciting KS. Essays and concept maps are considered to be highly related and complementary forms of assessment to evaluate KS (Clariana & Koul, 2004; Gonzalvo, Cañas, & Bajo, 1994; Koul, Clariana, & Salehi, 2005), especially if the concept maps are used as a scaffold or outline for writing and vice versa. There is empirical evidence that KS can be intentionally derived from existing artifacts such as a concept maps and essay (Clariana et al., 2004; Clariana, 2010; Jonassen et al., 1993; Koul et al., 2005).

For example, another pilot study #3 (Kim & Clariana, 2017) using the same KS analysis approach as in this present investigation, clearly demonstrated that combined mapping and writing activities were most effective for extracting KS after reading, then writing alone, and mapping alone is least effective. Based on these empirical findings, this current investigation employs both writing activity (essays) and making concept maps as a method to elicit the KS (i.e., as situation models) of individual readers.

2.3.1.1 Essays (Summary writing)

Following Emig’s (1977) view, writing closely resembles thinking and learning and is thus a concrete artifact or manifestation of cognition. Similarly, Bangert-Drowns, Hurley, and Wilkinson (2004) say,

...learning entails active, personal, and self-regulated construction of organized conceptual associations... the same features characterize writing. Writing requires the active organization of personal understandings. The externalization of those understandings in symbolic form makes them available for feedback... (p. 29).

Yu (2003) states that a good summary writing can prove useful for assessment of reading comprehension since it contains the relevant important ideas, distinguishes accurate information from
opinions, and reflects the structure of the text itself. More specifically, having readers write summaries is a promising approach since: (1) there is considerable empirical support that it both measures and encourages reading comprehension and is an effective instructional strategy to help students improve reading skills (e.g., Theide & Aderson, 2003); and (2) it is a promising technique for engaging students in building a mental representation of text (e.g., Clariana, 2010).

Kieras (1981) showed that when paraphrasing a text after reading (i.e., summary writing), readers tend to not reproduce the original embedding structure of the presented propositions but alter the propositions of the text to be more like their personal KS, so there may be little similarity in the embedding structure between the presented and paraphrased propositions. This finding suggests that text summary is a good way to probe the KS of readers because the written summaries attain some and maybe most of the reader’s underlying KS. Ifenthaler, Pirnay-Dummer, and Seel (2010) argued that using natural language responses (e.g., especially student’s essays) is likely to more accurately represent the meaning and structure of the targeted internal knowledge, and thus contain at least a reflection of an individuals’ internal mental structure. These studies above have provided evidence that summary writing can be a good way to elicit readers’ KS.

2.3.1.2 Concept maps

Unlike essays, concept maps (CMs) can offer a visual and holistic way to describe a number of concepts and their interrelationships. CMs and other similar graphical representations are one way, and maybe the most explicit way, to elicit and visualize KS of content (Jonassen, et al., 1993). Kraiger, Ford, and Salas (1993) assumed that learning outcomes are multidimensional and that a construct-oriented approach should be taken in the development of evaluation measures. The National Research Council recommended assessing the structure of knowledge, or knowledge organization, as a key indication of meaningful learning (NRC, 2001). Kinchin (2013) also maintained that a CM provides a snapshot of students’ understanding that is captured in time by drawing it out on paper or on a computer screen.
Then, which aspects of knowledge can be elicited, or captured, by a CM? Previous research has shown that proposition data (links between terms) of a CM were more related to verbatim knowledge covering facts, terminology, and definitions; whereas association data (distance between terms) of a CM were more related to gist knowledge such as comprehension, inferential, higher order knowledge (Clariana, Koul, & Salehi, 2006; Goldsmith & Davenport, 1990; Poindexter & Clariana, 2006; Taricani & Clariana, 2006). These findings suggest that links and distances between terms in a node-link-node assemble represent different important aspects of KS. However, the mapping prompt used can differentially elicit one at the expense of the other; for example requiring participants to create hierarchical maps increases the importance of propositional relations and decreases the importance of the spatial relations in the map artifact (Clariana, 2010).

Thus, this present investigation provided mapping directions that intentionally deemphasized propositions (links between terms) and that emphasized association (distance between terms) to more clearly measure and compare participants’ reading comprehension. For this reason, this investigation avoids using the terminology, concept map, because this study uses CMs without link labels and hierarchies which do not conform to a concept map defined by Novak and Gowin (1984). Instead, this study uses the term, ‘sorting task’, described by Clariana (2010), where students just move related concepts closer together and unrelated ones further apart until it feels right to them, in order to form the ‘structure’ based on the distance between the concepts (i.e., proximity), which can be supported by the report showing that link labels may not be critical for concept map analysis (Harper, Hoeft, Evans, & Jentsch, 2004). Also, since some KS elicitation tasks are more difficult than others, it is important to have a cognitively easy task that is comparable for bilinguals with different L2 levels (Hell & Kroll, 2013). Term-sorting task is an easy non-hierarchical task compared to writing, recalling from memory, or even concept mapping, and so it could be more tapped into the bilingual’s KS that might be distorted by difficult production tasks; for example, if the individual is not a good writer. Several pilot studies and other reading studies have demonstrated that such spatial-term sorting task is a sensitive way for assessing readers’ high-dimensional reading comprehension in both L1 and L2 (e.g., Clariana et al., 2014; Fesel et al., 2015; Kim et al., 2015, 2016; Tang et al., 2016).
2.3.2 Representing knowledge structure

This investigation applies Pathfinder Network algorithm to convert all essays and sorting tasks into Pathfinder Networks (PFnets) for comparison, which are hypothesized to represent the most salient organization, or structure, of the data (Azzarello, 2007). Pathfinder analysis software (Schvaneveldt et al., 1989; available at http://interlinkinc.net/) was designed as a psychometric scaling approach based on graph theory that utilizes a ‘triangle equivalence’ algorithm to determine shortest paths in sets of association data in order to reveal underlying structure of the data. For example, the sum of the distances of two sides of a triangle must be larger than or equal to the other side. As an example shown in Figure 2, the distance between concept A and B is 3, but the sum of the distances between concept A-C and C-B is only 2, so the direct A-B link will be removed.

![Figure 2](image_url)

Figure 2. The dash link (A-B) violates triangle equality so the link will not be linked in a PFnet.

The Pathfinder scaling allows for an extension of the triangle equality by changing the two parameters indexed in the PFnet algorithm, q and Minkowski’s r; the PFnet is the simplest network when the parameters r and q have the values $\infty$ and n – 1 respectively, where n is the total number of nodes in a network (see Schvaneveldt, 1998, for detail). These parameters ($r = \infty, q = n-1$) for computing the least-weighted path, or most direct path, are believed to remove less salient links. Thus, the resulting PFnet is comprised of all of the original nodes and the links that are not removed by the algorithm, i.e., the algorithm with particular r and q eliminates much of the complexity, or visual noise, of the original data (see Figure 3 for example); the Pathfinder network is “a fuller representation of the salient semantic structure…but also a more accurate representation of local
structure than multidimensional scaling techniques” (Chen, 1999, p. 408).

Thus, a PFnet is purported to measure the most salient linkages between co-occurring concepts (Clariana, 2010), and so show how the individual apprehends the interrelatedness - an organization of the concepts (KS) - in the specific content domain (Goldsmith et al., 1991; Schvaneveldt, 1990).

![Diagram of PFnet](image-url)

Figure 3. Examples of a fully connected PFnet with 17 concepts (left) and the reduced PFnet showing the most salient links among the concepts by setting $r$ and $q$ equal to $\infty$ and $n-1$ respectively (right)

The Pathfinder technique has been employed in diverse domains, including team performance studies (Lim & Klein, 2006), software requirements (Kudikyala & Vaughn, 2005), flight training (Schvaneveldt, Beringer, & Lamonica, 2001), police training (Braverman, 1997), categorizing satellite images (Barb, Clariana, & Chi-Ren, 2013), essays scoring (Clariana, et al., 2009), L1-L2 transfer (Kim & Clariana, 2015), and recently neuroscience studies (Li & Clariana, 2017). These studies have provided enough evidence that PFnet is a well-established system for deriving and representing the organization, or structure, of data.

### 2.3.2.1 Sorting task converted to Pathfinder Network

For converting sorting tasks into PFnets, Jrate software (available from [http://endaemon.net/jRateSuite](http://endaemon.net/jRateSuite)) is used to calculate the raw proximity data that contained all pair-wise
distance between the key terms in the participants’ sorting tasks. For example, this current investigation used 17 key term for analysis, so all of the participants’ sorting tasks were converted via *Jrate* into a proximity file with 136 elements, calculated as \((17^2 - 17)/2 = 136\), with number of terms \(n=17\), that are the distances in pixels between every terms. Using the *Knowledge Network and Orientation Tool* (KNOT), all of the participants’ sorting task proximity data were converted into *PFnets* (see Figure 4 for example); see Tang et al., 2016, for validity of sorting maps converted to *PFnets* in L2 reading research.

Figure 4. Example of a sorting task (*left top*), distance array for the sorting task from *Jrate* (*right top*), and its *PFnet* from KNOT (*bottom*).
2.3.2.2 Essay converted to Pathfinder Network

For converting essays into PFnets, ALA-Reader software (Clariana, 2004; available at http://www.personal.psu.edu/rbc4/score.htm) was used to transform the Korean and the English essays into raw proximity data. The ALA-Reader software tool captures the sequence of the preselected key terms in a text, in this case the same 17 key terms, as pair-wise links in a proximity file. More specifically, ALA-Reader disregards all of the words except for preselected key terms, and the synonyms and metonyms of key terms are replaced with the appropriate key terms. Then the software begins to search through the text from the beginning to the end sequentially. The software adds a ‘1’ in the proximity link array to indicate a link between a pair of consecutive terms, each succeeding term is linked to the next key term found. The software continues to aggregate linearly into the array until all of the text is processed.

Using the same approach described for sorting task analysis above, all of the participants’ essay proximity data were converted via KNOT into PFnets (see Clariana et al., 2014, for validity of ALA-Reader + PFnet approach). Once all sorting tasks and essays are converted to PFnets, then the KS elicited as sorting tasks can be compared to sorting tasks, as essays can be compared to essays, and remarkably, the KS of sorting tasks can be compared to the KS of essays.

This ALA-Reader + PFnet approach has also been used to analyze the KS inherent in text in diverse domains within and also across languages; for example, to determine individual and group knowledge convergence in an online course (Draper, 2013), to establish text structure of lesson texts for comparison to students’ essays (Fesel et al., 2015), to describe the effects of L1 on L2 reading (Kim et al., 2015), and recently to understand neural mechanisms underlying reading comprehension by comparing KS patterns with brain network patterns (Li et al., 2017).

Also, the ALA-Reader + PFnet approach has been favorably compared to other text assessment technologies, including global-scale (implicit) semantic space models such as Latent Semantic Analysis and Hyperspace Analogue of Language (LSA and HAL; e.g., Su et al., 2010) and also to local-scale (explicit) semantic models such as T-MITOCAR and CMM (e.g., M.K. Kim, 2012).
Overall, these investigations reported a similar or better KS measures of *ALA-Reader* in reading comprehension; for example, Su and Hung (2010) showed that Chinese essay scores using *ALA-Reader* outperformed LSA, a commercial essay scoring system. Also a *PFnet* graph is a visual display of KS, allowing quick visual examination and comparisons between network graphs while LSA text analysis is a ‘black box’ and only provides a numeric score.

However, the *ALA-Reader + Pathfinder* approach is not automated, which can limit the research with a large number of participants. For this investigation, I used a recently developed browser-based online version of *ALA-Reader + Pathfinder*, called *GIKS* (Graphical Interface of Knowledge Structure), that can automatically provide individualized KS as a *PFnet* of their writings and also show the similarity and difference in terms of the referent KS (e.g., lesson text) using different colored link lines (see Figure 5 for example). The GIKS tool was developed with grant funding from the *Center for Online Innovation in Learning* (COIL, https://coil.psu.edu/).

![Figure 5. GIKS screen shot of PFnet from a lesson text (left), *The Circulatory System*, and a student’s summary essay (right). Yellow indicates ‘missing’ links (perhaps due to a lack of understanding of the relationships between the yellow key concepts) and red indicates ‘incorrect’ links (perhaps due to a misunderstanding of the relationships between the red key concepts).](https://example.com/figure5.png)
2.3.3 Comparing knowledge structure

The resulting PFnets can be compared with other PFnets; for example, (1) a learner’s PFnet can be compared with an expert’s to identify knowledge gains, lacks, and misunderstandings (e.g., d’Apollonia, Charles, & Boyd, 2004); (2) “Before” and “After” PFnets can be compared to examine KS changes during instruction (e.g., Day, Arthur, & Gettman, 2001); and (3) learners’ PFnets can be compared to determine how different treatments influenced learners’ KS (e.g., Clariana, Draper, & Land, 2011). Then, how can PFnets be compared? For that, this investigation employed two established ‘graph-theoretic’ PFnet analysis methods: Similarity of PFnet and Centrality of PFnet.

2.3.3.1 Similarity of PFnets

KNOT software generates two main procedures for measuring PFnets: Pearson correlation of raw proximity data and Similarity of the derived networks (e.g., as common similarity and as configural similarity). First, the correlation rating provided by KNOT tool computes the Pearson correlation between the raw proximity data in two PFnet files. In brief, KNOT tool computes the Pearson correlation (r) between the raw proximity data in two PFnets, a measure that ranges from -1 to +1, with 0 indicating no association and 1 indicting perfect association. For example, the distances between pairs of nodes in one participant’s PFnet were compared to the distances between the same pairs of nodes in another participant’s PFnet. Many researchers have attempted to use this correlation value of PFnets to measure reading comprehension, because as explained above (refer back to section 2.3.1.2) distances between terms are more associated with higher-dimensional gist knowledge such as comprehension, relative to the links between terms that are more related to low-dimensional verbatim knowledge such as propositions (Clariana, et al., 2006; Goldsmith & Davenport, 1990; Taricani et al., 2006). Recently, such distance analysis has proved to be a sensitive way for assessing readers’ high-dimensional reading comprehension in both L1 and L2 reading contexts (e.g., Clariana et al., 2014; Fesel et al., 2015; Kim et al., 2015, 2016, 2017; Tang et al., 2016). A pilot study #1 (Kim, 2017) used this Pearson correlation parameter, so more detail explanation is provided in section 3.1.3.2.
KNOT software also provides two similarity parameters: common similarity and configural similarity. The common similarity measure is simply the total number of common links in common shared by two PFnets. The configural similarity of two PFnets (sets) is calculated as the intersection divided by the union (the number of uncommon links is that the total number of links in both PFnets minus the number of links in common), configural similarity ranges from 0 (no similarity) to 1 (perfect similarity). Pathfinder network similarity scores have been empirically used in various studies to predict self-efficacy (Davis, Curtis, & Tschetter, 2003), achievement (Chen, 1997; Goldsmith et al., 1991), and behavior (Gomez, Hadfield, & Housner, 1996), prior knowledge effect for reading (Clariana & Koul, 2008) (see for more application of Pathfinder similarity score, Coronges et al., 2007; Monge & Contractor, 2003; Poindexter & Clariana, 2006; Taricani et al., 2006). Note that a growing list of more than 250 research studies using Pathfinder correlation and similarity is available at http://interlinkinc.net/References.html).

2.3.3.2 Centrality of PFnets

Centrality is another graph-theoretic measure that has recently been applied to PFnets. Centrality is useful and usable in KS studies although it was popularized to study social relationships. Centrality measures provide both a global-level measure that describe a network form or structure (i.e., graph centrality) and a local-level measure that describes node importance (i.e., node centrality) of a PFnet. Thus, using centrality measures could provide more insights into KS research in that it generates new and various network parameters that can be compared to a benchmark network or other networks.

First, the centrality of a node in a graph indicates the relative importance of that node in the graph. As an illustration, in a social network, an individual with the most links to other people may be the most influential person in that setting. Likewise, the concept (node) with the most links could be probably pretty important compared to other concepts with fewer links. Clariana et al. (2013) applied node centrality (i.e., the number of links to a concept) to mathematically and visually describe
cognitive state changes from problem space to problem solution during problem solving. Participants (n=120) were randomly assigned to interdependent or non-interdependent conditions to work online in triads to create a concept map to solve a problem scenario. Node centrality of the interdependent group-created concept maps resembled the fully explicated problem space, while the non-interdependent group-created concept maps mainly resembled the problem solution, which aligned with the results using human raters’ ‘manual’ common relations count CM analysis. This finding demonstrated that node centrality can provide supplementary measures of KS (see another applications of node centrality, Haiyue & Yoong, 2010; Wouters, van der Spek, & van Oostendorp, 2011) – more detail explanation for node centrality is provided in the pilot study section 3.1.

The application of the node centrality in a graph can be extended to determine a centrality value of a whole graph (i.e., graph centrality; a measure of network form, or structure). Clariana et al. (2011) quantified the four network graph layout forms using graph centrality as a numerical measure of network graph structure that ranges from 0.1 (linear form), 0.4 (a hierarchical form), 0.6 (a network form), and 1.0 (a star form), with optimally relational and complex networks typically falling around 0.4 to 0.5., and then this range of graph centrality values has been qualitatively characterized into a “conceptual typology (Kinchin et al., 2000)”; linear form indicates goal-orientation, hierarchical form indicates expertise, and star form indicates a naïve epistemology (see Figure 6).

Figure 6. Graph centrality calculated for four concept map forms from Clariana et al. (2011)

Clariana et al. (2011) applied graph centrality to analyze end-of-course essays of participants (n = 121) in either collaborative or individual self-paced groups. After a 3-months long online course,
the group average KS of the participants in a collaborative online group converged toward a more expertise *hierarchical* structure like an expert (i.e., field representative) relative to a self-paced group that showed goal oriented *linear* KS ($C_{graph} = .45$ vs. .25).

In order to further validate the application of centrality of *PFnets*, several pilot studies applied both graph and node centrality beyond monolingual settings into Korean-English bilingual settings (Kim & Clariana, 2015, 2016, 2017). For example, Kim et al. (2015) applied both graph and node centrality to explore how bilingual readers’ L2 reading processing interacts with their L1 by visualizing L1 and L2 situation model KS of participants (n=50) in either a Directed Writing or Translated Writing modes. The low proficient participants read the same L2 expository lesson text and then completed sorting tasks and summary writing as their situation models of the L2 text, with or without intervening L1 production tasks. The graph centrality results indicated that the Directed Writing group’s (L2 only use) cognitive state changes in KS on average were somewhat *linear* in form (ranged from .23 to .34) while the Translated Writing group’s (both L1 and L2 use) cognitive state changes in KS were all *relational* forms (ranged from .46 to .57) like that of the content expert (.47), and the relational structure had a significant correlation with their comprehension posttest performance in L2. This result from graph centrality suggests that the KS ‘form’ of the participants in the Translated Writing condition (L1 use group) were a network-like *relational* structure like the expert, relative to the Directed Writing condition (L2 only use group) that had a more *linear* structure, suggesting a fundamental way that L1 and L2 reading processing results in different post-reading memory traces. The pilot study assumed that latent rich (relational) L1-based KS could be *conceptually* imparted to their meager (linear) L2-based KS, and the L1-like L2 KS can positively affect L2 reading comprehension.

The node degree analysis results precisely corroborated the pattern observed in the graph centrality analysis in that the Translation group’s KS “directional” shift in the multidimensional scaling (MDS) representations of the map node vector data indicates KS convergence with the Expert map while the Direct group’s KS transformation was fairly evenly distributed across the MDS figure.
with no clear “directional” shift, and if any shift is present, it is a bit more toward the right, away from the Expert map (see Figure 7).

![Figure 7](image.png)

**Figure 7.** The Proxscal 2-dimensional representation of the map node centrality data. T indicates the Translation group while D indicates the Direct group’s maps, Blue indicates Premap and Red Postmap, and the numbers indicate the individual participant ID, from Kim et al. (2015).

The investigations cited above showed that centrality measures provide a different vantage point and descriptive frame as a visually-based measurement approach of mental representations. This present investigation, thus, employed both graph and node centrality analysis as an alternate and complementary measure of a traditional analysis, Correlation and Similarity of PFnet. Then, how is graph centrality and node centrality calculated? First equation 1 below is used to scale the graph’s node degree centrality values. Next equation 2 is to calculate the graph centrality values.

**Eq. 1, Degree centrality of each node:** $C_{D}(v) = \frac{\text{deg}(v)}{(n-1)}$

**Eq. 2, Degree centrality of a graph:** $C_{D}(G) = \sum_{i=1}^{V} \frac{[C_{D}(v^*) - C_{D}(v_i)]}{(n-2)}$

Here, $v$ = vertex (each concept or node included in the map), $\text{max}C_{D}(v_i)$ = vertex with the highest degree centrality, $n$ = number of concept nodes in the map, an $G$ = graph. As an example, the
The calculation of node centrality (Eq. 1) and graph centrality (Eq. 2) for the linear and star graphs from Figure 6 is shown in Table 1.

Table 1. Example of node and graph degree centrality for the “linear” and “star” graphs shown in Figure 6, from Clariana et al. (2011).

<table>
<thead>
<tr>
<th>node degree count</th>
<th></th>
<th>Eq. 1</th>
<th></th>
<th>Eq. 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>linear</td>
<td></td>
<td>star</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>0.20</td>
<td>1.00</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b</td>
<td>0.40</td>
<td>0.20</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c</td>
<td>0.40</td>
<td>0.20</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>0.40</td>
<td>0.20</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e</td>
<td>0.40</td>
<td>0.20</td>
<td>e</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f</td>
<td>0.20</td>
<td>0.20</td>
<td>f</td>
</tr>
</tbody>
</table>

The degree centrality of a graph = 0.10 1.00

2.3.4 Summary

KS likely reflects the organization and interrelationships of the knowledge within a particular domain (Diekhoff, 1983; Jonassen et al., 1993). Consequently, KS has been recognized as important in the fields of education and educational assessment. Several studies have demonstrated that measures of content KS have been empirically and theoretically related to memory, classroom learning, insight, novice-to-expert transition, and reading comprehension in L1 and L2, as explained above. The working assumption of this investigation is that persistent KS exists and influences cognition in a way that can be expressed as a nomological network, and the KS influence can be measured and is worth measuring.

The KS measure generally involves a three-step procedure: (1) Eliciting KS; (2) Representing KS; and (3) Comparing KS. As the first step, KS can be intentionally elicited from existing artifacts such as essays and sorting tasks. Next, KS elicited as essays and sorting task artifacts can be transformed into PFnet for comparison, and the PFnet can be evaluated by comparing it to a referent (i.e., another PFnet).
2.4 Conclusion

L2 reading is a complex process involving reader-based and text-based factors. This investigation proposes that L2 proficiency is directly due to the establishment of rich KS. A pilot study #1 (Kim, 2017) in section 3.1 will explain in detail that L2 proficiency is the most powerful predictor of L2 reading comprehension among reader-based factors, consistent with previous L2 reading studies (e.g., Ellis, 2008; Gass, 2013). Given the interactive process of reading between a reader and a text, however, text-based factors such as text genre will make important contributions to the L2 reading processing. L1 reading research has clearly established that text genre is an important predictor of reading comprehension, and narrative texts are much easier to comprehend than expository texts. However, these results have not yet been reproduced in the L2 setting, where the very few studies that examined this relationship between text genre and L2 reading comprehension have obtained conflicting results. In addition, given the significant contribution of L2 general proficiency to L2 reading, the question of the relationship between text genres and L2 proficiency level remains open, although some research suggests that genre-level cues that may facilitate comprehension are only accessible to high proficiency L2 readers. Also, the interaction of prior knowledge and text genres has not even been investigated in L2 text genre research as far as I can determine. These unclear and few reported findings in L2 reading may be largely due to methodological difficulty because L2 reading is an extraordinarily complex, multidimensional process involving both reader-related and text-related factors that are far more varied than in L1 reading. For this reason, this investigation proposes a recent KS analysis model to better understand the reading processing differences that may be triggered by the use of different text genres in L2 context.

Few L1 and L2 reading studies have conceptualized KS in this way. If this KS approach is supported, then L2 reading can be scrutinized in a more in-depth manner, whereby it should be possible to provide further insights into L2 reading, thus also enriching the KS approach to reading research in both L1 and L2. Also, it could provide researchers with another measurement tool to better understand the mediating influence of lesson tasks on learning processes and outcomes.
Chapter 3
METHODOLOGY

The methodology for this experimental study is adapted from methods used in the pilot study conducted in spring 2015. I therefore begin with a brief discussion of the pilot study’s methodology, results, and implications for the present study. This is followed by a description of the methodology used in the present study.

3.1 Pilot study

3.1.1 Research questions

In this pilot study #1 (Kim, 2017), my research questions were focused on determining (1) how L2 reading interacts with L1 (by comparing pre-to-post sorting patterns in L1 and L2 within the same readers), (2) how language proficiency modulates the interaction (by comparing pre-to-post sorting patterns across groups of readers: low proficiency and high proficiency), and further (3) whether L1 or L2 differently influences their L2 text comprehension (by comparing L1 or L2 post-reading sorting patterns to the expert’s sorting pattern and the comprehension posttest).

3.1.2 Pilot method

The pilot study was conducted with both high proficient English Language Learners (ELLs, n=68) and low proficient ELLs (n=68) enrolled at a large South Korean-based University. All participants were randomly assigned to four treatments (n=68, 17 per condition, of the high proficiency; n=68, 17 per condition, of the low proficiency) in terms of the sequence in sorting tasks and reading text, including K-reading-K, K-reading-E, E-reading-K, and E-reading-E, where K is the Korean sorting task as an L1 and E is the English sorting task as an L2 and the reading is in English in all conditions (see Figure 8).
First, (1) participants completed a sorting task training lesson on how to draw diagrams for sorting tasks (about 10 min), (2) then they were given a paper handout with a list of 20 key terms from the lesson text (either in L1, Korean, or in L2, English, depending on treatment) and were asked to sort the given key terms to form their “pre-reading KS” based on their innate understanding from the given key terms; but they were instructed “you could use any terms and any numbers of terms in your sorting map”, i.e., open-ended mapping. Next, after the pre-sorting task, (3) they were required to read a 706-word expository TOEFL text, The Cave of Lascaux, taken with permission from Educational Testing Service (ETS), and (4) then they were asked to sort the same given key terms to form their “post-reading KS” based on their understanding of the text on the same handout. Finally, after the post-sorting task, immediately (5) all participants were asked to complete the multiple-choice posttest developed by ETS that consisted of 10 comprehension-related items - the posttest had an acceptable level of internal consistency, as determined by a Cronbach’s alpha of .805 in this investigation.

To establish a benchmark model for comparison analysis, three content experts were provided with a list of all of the terms used by the participants in their sorting maps, in the order of frequency of occurrence. While considering the list and the lesson text, the three content experts had collaborated to reach consensus on 10 essential terms (English: cave painting, puzzling, location, seasonal migration, hunting ceremony, tribal ceremony, motivation, overpainting, ancient human, intelligent; Korean: 동굴벽화, 퍼즐, 위치, 이주, 사냥의식, 부족의식, 동기부여, 겹칠, 고대인, 지
that can represent the topic structure of the expository lesson text and then created a single expert referent sorting map using the 10 essential terms. This expert sorting map was used as the benchmark referent sorting map for comparison to the participants’ sorting maps.

For the sorting tasks analysis, all pre- and post-sorting tasks were converted into PFnets by the process (i.e., Jrate & Pathfinder KNOT) that was explained in detail in the 2.3.2.1 section. Thus, the PFnets from the pre-to-post L1 and L2 sorting tasks could be directly compared to each other, and also to the expert’s PFnet (see Figure 9 for example).

Figure 9. Example of a student’s English (top) and Korean (bottom) sorting map, distance array from Jrate, and PFnet from KNOT.
The participants’ PFnets (as their KS) from their pre-to-post reading sorting patterns were compared within and across participants to address question 1, 2, and further with the content expert’s PFnet (as the expert KS) to address question 3. For the PFnet analysis, the pilot study employed both Pearson Correlation of term proximity data and Centrality of PFnets that were explained in detail in sections 2.3.3.1 and 2.3.3.2, respectively.

3.1.3 Pilot result

The data for analysis consists of the comprehension posttest scores and 272 sorting maps [68 x 2 (proficiency groups) x 2 (pre- and post-sorting maps)] converted to PFnets. First, comprehension posttest data are presented, and then PFnet data are described and compared in four ways including Pearson correlation of PFnet raw proximity for: (1) analysis within-students between-tasks and (2) analysis between students within tasks, and a Degree centrality of PFnets: (3) node centrality and (4) graph centrality.

3.1.3.1. Comprehension Posttests

Reading comprehension as posttest. A two-way ANOVA was conducted to examine the effects of two factors, language (L1 or L2) and proficiency (Low or High), on the comprehension posttest. The two-way ANOVA showed significant effect for language, $F(1,52) = 189.41, p = .01$, partial $\eta^2 = .88$; for proficiency level, $F(1,52) = 17.06, p < .01$, partial $\eta^2 = .58$; for the interaction of language and proficiency level, $F(1,52) = 7.32, p = .02$, partial $\eta^2 = .32$. Note that the low proficiency readers scored higher on the posttest when they used L1 than L2 for their post-reading sorting tasks, $p = .002$; whereas there is no difference between L1 and L2 for the high proficiency readers, $p > .05$ (see Table 2).
Table 2. Average MC posttest score of all groups (SD), PFnet similarity Fisher z means to the expert as Expert, and to the individual Posttest as Posttest.

<table>
<thead>
<tr>
<th></th>
<th>Proficiency</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td><strong>MC posttest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>--</td>
<td>4.6 (1.02)</td>
<td>--</td>
<td>8.8 (1.16)</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>--</td>
<td>2.1 (0.98)</td>
<td>--</td>
<td>9.1 (2.01)</td>
<td></td>
</tr>
<tr>
<td><strong>Expert</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>0.06</td>
<td>0.58</td>
<td>0.09</td>
<td>1.53</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>0.10</td>
<td>0.18</td>
<td>0.14</td>
<td>1.42</td>
<td></td>
</tr>
<tr>
<td><strong>Posttest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>0.15</td>
<td>0.56*</td>
<td>0.16</td>
<td>1.42**</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>-0.12</td>
<td>0.23</td>
<td>0.28</td>
<td>1.29**</td>
<td></td>
</tr>
</tbody>
</table>

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Reading comprehension as PFnet similarity. I also computed the similarity between participants’ pre-to-post PFnets and expert’s PFnet, measured by correlation between theirs and the average expert’s PFnet, because if the readers comprehend the expository text as the expert intended, then the expert’s KS would be reflected in their KS; for example, looking forward to the results in this investigation, better KS engenders better comprehension posttest performance. Note that since correlation values (r) are not interval-level data, Fisher’s r to z transformation was applied to the correlation values using an Excel spreadsheet prior to averaging and statistical comparison of the PFnet files. Then these Fisher z values were averaged and compared to each other and to the expert.

A three-way ANOVA was conducted to determine the effects of language (L1 or L2), proficiency (Low or high), and time (Pre or Post) on the mean similarity. There was a significant three-way interaction between language, proficiency, and time, $F(2,60) = 7.406, p = .001$, partial $\eta^2 = .881$. There was a significant simple two-way interaction between language and time for low proficiency, $F(2,60) = 5.252, p = .008$, partial $\eta^2 = .557$, and for high proficiency, $F(2,60) = 8.78, p < .01$, partial $\eta^2 = .444$. There was a significant simple main effect of language at a post-sorting phase for low proficiency, $F(2,60) = 14.766, p = .001$, partial $\eta^2 = .546$, but not significant for high proficiency, $F(2,60) = 0.660, p = .521$. The significant interaction is shown in Figure 10.
Figure 10. The two-way interaction of similarity to the expert before and after reading for low proficiency (left) and high proficiency (right) participants; the solid line shows L1 and the dashed line L2.

For the low proficiency readers, a notable finding is that their L1 post-reading KSs have a significant relationship with the comprehension posttest ($Fisher \ z = 0.56$, $est. \ r = 0.51$) relative to their L2 post-sorting KSs that have no significant relationship with the posttest. For the high proficiency readers, their post-reading KSs have very strong significant relationships with the comprehension posttest regardless of languages ($Fisher \ z = 1.42, 1.29$, $est. \ r = 0.89, 0.86$, respectively).

3.1.3.2 Pearson correlation of PFnet raw proximity

a. Analysis within student’s two sorting task (mental model stability and the influence of the text)

Data for the analysis consisted of the two sorting tasks completed by every participant, one before and one after reading an L2 text. Each student’s raw proximity distance data between the 10 terms in a pre-sorting task (i.e., 10 terms obtains 45 distance vectors between those terms) were compared by Pearson correlation to those of the same student’s post-sorting task, and then this correlation value ($r$) is transformed into a Fisher ($z$) value. These pre-to-post Fisher $z$ values from each student in a treatment are averaged together to get an average pre-to-post group average. The within student analysis is applied to all four treatments (treatments are: K-read-K; K-read-E; E-read-K; E-read-E) (see Table 3).
Table 3. Within student raw proximity pre-to-post sorting task Fisher z means and standard deviations (in parenthesis) for each treatment in both high proficient and low proficient groups.

<table>
<thead>
<tr>
<th></th>
<th>Low proficient group</th>
<th>High proficient group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$K$-read-<em>K</em></td>
<td>$K$-read-<em>E</em></td>
</tr>
<tr>
<td>$n=17$</td>
<td>$n=17$</td>
<td>$n=15$</td>
</tr>
<tr>
<td>Grand mean</td>
<td>0.39</td>
<td>1.13</td>
</tr>
<tr>
<td>n=60</td>
<td>(0.16)</td>
<td>(0.21)</td>
</tr>
<tr>
<td></td>
<td>$n=52$</td>
<td></td>
</tr>
<tr>
<td>Grand mean</td>
<td>0.17</td>
<td>0.28</td>
</tr>
<tr>
<td>n=52</td>
<td>(0.09)</td>
<td>(0.10)</td>
</tr>
</tbody>
</table>

For the low proficiency readers, their data set shows a strong relationship between pre-to-post grand mean values compared to the high proficiency readers. The low proficiency readers’ average pre-to-post Fisher z values range from .39 (approximately 14% overlap) to 1.13 (approximately 66% overlap), while the high proficiency readers’ average pre-to-post Fisher z values range from .17 (approximately 3% overlap) to .28 (approximately 7% overlap). A conspicuous difference in the low proficiency data set is the strong relationship between “K-to-E” pre-to-post sorting maps ($z = 1.13$, approximately 66% overlap) compared to other pre-to-post sorting maps (range $z = .39$ to .71, approximately 14% to 37% overlap). Given their low proficiency level in English, I assume that K-to-E members’ L2 (English) post-reading KS heavily relied on their L1 (Korean) pre-reading KS, which could mean that their L2 post-reading KS might not be as much influenced by the L2 text base. If so, interestingly, K-to-K members’ L1 post-reading KS did not depend on their L1 pre-reading KS ($z = .39$, 14% overlap) in contrast to the K-to-E (66% overlap), which could mean that K-to-K members’ L1 post-reading KS might be substantially influenced by the L2 text base.

To sum up, the low proficiency readers’ within-student KS analysis indicates that their post-reading KS was more like the L2 text base when the L2 text was reframed by the L1 post-reading sorting task (e.g., the K-to-K and E-to-K conditions), apparently the L1 KS strongly influenced the KS established in L2, at least for these low proficiency Korean ELLs.
For the high proficiency readers, their data show small values of overlap between the four pre-to-post sorting maps. Given their high proficiency in English, their post-reading KS would be strongly influenced by the L2 text base regardless of which language is used for their post sorting tasks. The high proficiency readers’ within-student KS analysis indicates that their post-reading KS was more like the L2 text base in both languages.

b. Analysis between students, within tasks (convergence)

Group member convergence is defined here as the similarity of a student’s KS to that of other students within a condition. Here, group KS convergence is measured as average percent overlap of all participants’ sorting tasks in a condition. In other words, how similar were peers sorting tasks? To represent the percent overlap as a measure of convergence, every student’s raw proximity distance data was correlated to every other student within their condition and then r values were squared into coefficients of determination ($r^2$). Note that the Pathfinder KNOT tool can automatically calculate this group convergence (see Table 4, Figure 11).

Table 4. Within condition KS convergence as average percent overlap for the low and high proficiency groups

<table>
<thead>
<tr>
<th></th>
<th>Low proficiency average percent overlap (SD)</th>
<th>High proficiency average percent overlap (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>K-to-K</td>
<td>16% (.15)</td>
<td>47% (.12)</td>
</tr>
<tr>
<td>K-to-E</td>
<td>14% (.14)</td>
<td>15% (.18)</td>
</tr>
<tr>
<td>E-to-K</td>
<td>9% (.10)</td>
<td>44% (.27)</td>
</tr>
<tr>
<td>E-to-E</td>
<td>12% (.12)</td>
<td>14% (.19)</td>
</tr>
</tbody>
</table>
Figure 11. KS group convergence by proficiency level. Solid indicates ‘high proficiency’ and dash indicates ‘low proficiency’.

For the low proficient group, the pre-reading sorting tasks’ average overlap percent of individuals in each treatment condition is quite small perhaps due to their innate pre-existing different understanding of the given terms. Regarding their post-reading sorting tasks, I expected that their post-reading sorting tasks would be more alike due to their similar understanding from the same text, but this is not the case for the L2 post-sorting tasks. The data show that the L1 post-reading situation models of different individuals are considerably more alike (47% overlap in K-to-K; 44% overlap in E-to-K) than are their L2 post-reading situation models (15% overlap in K-to-E; 14% overlap in E-to-E), which means that their L1 post-reading KSs are more homogenous (i.e., had more similar KSs) while the L2 post-reading KSs are still idiosyncratic. This convergence finding could indicate that the use of an L1 appears to help these low proficient ELLs who seem to have idiosyncratic KS for the term set before reading but have more homogenous KSs, for the same concepts after reading.

For the high proficient group, they also have unrelated pre-reading situation models like the low proficient group (maybe due to the same reason), but their post-reading situation models are considerably alike regardless of sorting languages. In other words, high proficiency readers’ post-reading KS strongly converged (i.e., had homogenous post-reading KSs) in both languages compared to their pre-reading KSs (i.e., had idiosyncratic pre-reading KSs). Given that the high proficiency
ELLs have a very strong KS lexical complexity in both languages, it may be reasonable for them to construct similar post-reading KS in both languages.

3.1.3.3. Centrality of PFnet

a. Graph centrality

   Recall that graph centrality is a holistic measure of network graphs “form” that are derived from the raw proximity distance data. For the low proficiency group, L1 post-reading KS on average had a quite relational structure (.53 to .51, respectively) like the expert (.47) relative to their L2 post-reading KS (.18 to .10, respectively) that had a linear structure, suggesting a fundamental way that L1 and L2 cognitive processing differs (see Figure 12). My working assumption is that a relational-hierarchical KS would be better able to make an inference from the text relative to the sequential-linear KS that should be better for verbatim knowledge tasks, and this was clearly supported by the patterns observed in their Pearson correlation analysis above (refer back to Tables 2, 3, and 4). It could be therefore suggested that when the L2 text was followed by the sorting task in L1, their post-reading KS converged towards a more complex relational structure (see Table 3, 4), and the relational KS shows a positive correlation with their L2 text comprehension performance (see Table 2), compared to when the same L2 text was followed by the sorting task in L2, leading to a linear KS.

   For the high proficiency group, as expected, post-reading KS in the four treatments had all substantially relational structure in both languages (.45 to .55 to .52 to .53, respectively, see Figure 12) and the results corroborate their Pearson correlation results (refer back to Tables 2, 3, and 4). It can be therefore suggested that high proficiency readers have a highly relational complex post-reading KS regardless of the language in which the L2 text is comprehended.
b. Node centrality

Recall that node centrality is another measure of network graph “form” that emphasizes or highlights the relative importance of each node in the network. Proxscal multidimensional scaling (SPSS 20.0) was used to visually represent each PFnet (as KS) as an individual point in a 2-dimensional space by using the 10-element node degree vectors used above to calculate graph centrality. As shown in Figure 13, the Expert KS fell toward the left of the figure. The dimensional representation shows a transformation of participants’ KS measured as node centrality from pre-to-post-reading sorting tasks.

For the low proficiency group (dash), since the two L1 post-reading KSs from the K-to-K and E-to-K conditions are towards the Expert, we infer that the K-to-K and E-to-K groups’ pre-to-post positions in the multidimensional scaling (MDS) representation indicate KS convergence with the Expert; whereas the other two L2 post-KSs are towards the right of the MDS figure, away from the Expert with no clear convergence. For the high proficiency group (solid), since all L1 and L2 post-situation models in all pre-to-post conditions ‘moved’ very close to the Expert, we infer that their pre-to-post positions indicate very strong KS convergence with each other and also with the Expert.
Figure 13. The proxscal 2-dimensional representation of the pre-to-post sorting task node centrality data. Note. K: Korean, E: English, Pre: pre-sorting task, Post: post-sorting tasks; Solid line indicates high proficient pre-to-post sorting tasks and Dash line indicates low proficient pre-to-post sorting tasks, where K is Korean and E is English.

Interestingly, the pre-to-post length of arrows could suggest the amount of pre-to-post KS changes over time. Given the long arrows of high proficiency pre-to-post conditions, it could be assumed that their KSs were considerably changed toward an expert after reading the L2 text; whereas, low proficiency participants KSs were changed toward an expert only when the L2 text was framed by the L1 post sorting tasks. Thus, this MDS node degree analysis visually depicts the Pearson correlation results.

3.1.4 Pilot discussion and implication for the present study

*Low proficiency readers:* This pilot investigation revealed that low proficiency participants post reading KSs depended on the language they used in the post-reading sorting tasks. When the L2 expository text was followed by the L2 post-reading sorting task, their post-reading KS heavily relied on their idiosyncratic pre-reading KS (see Table 3), which led to idiosyncratic linear post-reading KS (see Figure 12) that had no significant relationship with the expert’s KS nor with their posttest performance (see Table 2). Given their likely low ability to integrate individual L2 words into a
structured representation of sentences or text being read (Kroll & Stewart, 1994), they may be less able to construct appropriate meaning from text (i.e., textbase), and also situation models, so they seem to depend on their idiosyncratic pre-reading KS for the L2 text comprehension. Interestingly, when the same L2 text was followed by the L1 post-reading sorting task, their post-reading KS was considerably influenced by the L2 text passage (see Table 3), which resulted in a relatively complex relational post-reading KS (see Figure 12) that was significantly correlated with the expert’s and with posttest results (see Table 2). In sum, the PFnets visually demonstrate that the low-proficiency readers’ KS was differently influenced by the language of post-reading tasks (in this case, sorting task), suggesting a fundamental way that L1-and L2-derived KS differs, at least for these low proficiency Korean ELLs.

High proficiency readers: This pilot investigation revealed that high proficiency post-reading KSs had a highly relational structure in both languages, and both L1 and L2 post-reading relational KSs had a very strong correlation with their L2 text comprehension performance (see Table 1). Given their high language proficiency in both L1 and L2, their relational KS in both languages might be reasonable. In sum, the PFnets visually demonstrate that language itself doesn’t influence the high-proficiency reader’s KS, confirming the modality-independent cognitive procedure; for example, people who read about a certain event in a newspaper produced similar mental models as people who saw the same event on a TV. Likewise, comprehension of a text in a different language will also result in a similar KS because conceptual information is largely shared across two languages, if the bilingual readers are fully proficient in the two languages (Francis, 2005).

All in all, this pilot study #1 (Kim, 2017) not only enabled the researcher to understand the different pre-to-post KS interaction that can be triggered by task language, but also demonstrated the KS measure’s appropriateness and validity as useful and usable measures of KS contained in the English language learners’ pre-to-post reading production tasks (in this case, sorting tasks). However, the pilot study had several limitations. First, the pilot study used an unfamiliar text topic, The Cave of Lascaux, so participants’ pre-reading KS of that topic is quite idiosyncratic. With such an unfamiliar text topic, it may not be possible to draw precise conclusions regarding the effect of readers’ prior
domain knowledge on reading comprehension. Another problem is that the study employed only a sorting task as a method to both process and represent the situation model of L2 lesson text. However, given the results from another pilot study #3 (Kim & Clariana, 2017), combining a sorting task and writing activity was the most effective for influencing KS after reading, compared to the sorting task alone or writing alone, as evidenced by many other monolingual empirical studies (e.g., Jonassen et al., 1993). Based on the lessons from the pilot study results, the following changes were made in order to improve the quality of the present study.

(1) This present investigation chose a somewhat familiar new text topic, *The Circulatory System*, from a study by Wolfe and Mienko (2007) and subsequently also used in pilot study #2 (Clariana et al., 2014). By using this familiar text topic, it is expected that this present study can better detect the interaction between prior knowledge and reading comprehension by text genres.

(2) This investigation used an expository text and a parallel narrative text designed to present common content about *The Circulatory System*. A pilot study #2 (Clariana et al., 2014) conducted in L1 contexts with these texts has demonstrated that the KS approach is able to detect the text structure differences in a set of the lesson texts and in L1 readers’ summary essays of these texts. By using the same texts in this L2 context, thus, it is expected that this present study can examine how common content is represented differently in L2 readers’ summary essays based on the genre in which it is presented.

(3) This present investigation employed a summary writing activity along with sorting tasks as two methods to elicit and represent a situation model of an L2 text, as in pilot Study #4 (Kim & Clariana, 2015). By combining the two production tasks, it is expected that this present study can better elicit participants’ KS as their L2 text comprehension.
3.2 The present study

3.2.1 Experimental design

The present study seeks to expand upon the pilot study #1 (Kim, 2017) by examining the interactions between pre-reading KS and text genres and between text genres and post-reading KS. It investigated these interactions among a cross-section of Korean learners at two different levels of English (low & high proficiency). A design similar to the pilot study was used. Participants completed their pre-reading tasks (as sorting tasks), read either a narrative or expository text, and then completed post-reading tasks (as summary writing). Then all sorting tasks and writings were converted to PFnets for analysis. Due to the different nature of sorting and writing tasks as well as data structure difference, this present investigation employed Similarity of PFnet, used in pilot study #2 (Clariana et al., 2014), along with Centrality of PFnet as an alternative holistic measure of PFnets, used in another pilot study #3 (Kim & Clariana, 2017), to analyze participants’ pre-to-post PFnets. More detail can be found in the 3.2.4.3 procedure section.

3.2.2 Research questions

These research questions in this present study deal primarily with knowledge structure and test performances differences that arise for different text genres. These questions are presented in detail below:

1. What is the relationship between “pre-reading KS” and “text genre”?
   1a. Is the prior knowledge of a reader differently utilized by text genres?
   1b. How does language proficiency modulate the difference?

2. What is the relationship between “text genre” and “post-reading KS”?
   2a. Is there a difference in memory and learning of the L2 text content by text genre?
   2b. How does language proficiency modulate the difference?
3. Is the KS analysis effective and appropriate to describe the expected relationships between text genres and readers’ pre- and post-reading KS?

3.2.3 Hypotheses

The following hypotheses are proposed in responses to the research questions:

Q1) Based on L1 text genre research, it is expected that narrative text will facilitate the retrieval of related prior knowledge from memory to a greater extent than will expository text (e.g., Kintsch et al., 1984). However, given the pilot study reporting that low proficient readers tend to heavily rely on their prior knowledge when they have difficulty decoding L2 words and sentences and also completing L2 production tasks, the influence of prior knowledge is expected to be greater among the low proficiency than the high proficient participants.

Q2). Based on L1 text genre research, it is expected that participants at all levels will recall and learn significantly more from the narrative passages than from the expository texts (Schneider et al., 1989). However, given the significant contribution of L2 proficiency to L2 reading, as evidenced by pilot studies (Kim & Clariana, 2015, 2016, 2017) as well as previous L2 reading studies (e.g., Chen & Donin, 1997), the low proficiency readers may be less able to take advantage of the narrative text cues that facilitate memory and learning of the text content. Thus, the effect of narrative text genre relative to expository on memory and learning is expected to be greater among high proficient readers than low proficient readers.

Q3) Based on several pilot studies using KS analysis with Korean-English bilingual readers, the KS analysis methods will be expected to reveal the expected relationships of Q1 and Q2 (e.g., adequacy of the measurement and analyses approaches).
3.2.4 Method

3.2.4.1 Participants

This experimental investigation was conducted with both high proficient ELLs (n=296) and low proficient ELLs (n=320) enrolled at five large South Korean-based Universities. The participants ranged in age from 20 to 33 years, with 374 females (61%). As in the pilot study #1, this present study used two steps to filter participants’ proficiency levels. The first filtering is to use The Language History Questionnaire (LHQ 2.0; Li, Zhang, Tsai, & Puls, 2013), popularly used in L2 studies for assessing the linguistic background and for generating self-reported proficiency in multiple languages. The survey for the high proficiency participants revealed that 238 of these participants had previous experience living in English-speaking countries such as England, Australia, and the U.S for at least 8 years. Other high proficiency participants were masters or doctoral students who were majoring in English in the Korean universities and they had stayed in English-speaking countries for at least two years for their academic purposes. Questionnaire survey for low proficiency participants indicated that none of the students had any intermediate or higher level English instruction or experience, nor did they have previous experience studying English abroad.

The second round of filtering is to check each group’s official TOEIC (Test of English for International Communication) score - the most widely accepted measure of English ability in Korea (The Korean Herald, 2015). Note that the TOEIC score is a mandatory requirement for job seekers in Korea, so almost all young Korean job seekers have their TOEIC scores regardless of their major. The students who have an official TOEIC score, which has been shown to be a valid and reliable measure of English learners’ proficiency (Jamieson, Enright, & Chapelle, 2008), were permitted to participate in this experiment. The average TOEIC score for the high proficiency was $M = 905, SD = 2.42$, which is considered as professional proficiency in English by ETS (Powers, 2010), and for the low proficiency was $M = 321, SD = 3.29$, which is considered as elementary proficiency in English. Then I excluded some of the participants from each group by ‘reading’ only score. For example, if participants in the high proficiency had a reading score below the average then I excluded the
participants from the high proficiency group while if participants in the low proficiency had a reading score above the average, then the participants were excluded from the low proficiency group. The average TOEIC reading score for the high proficient participants was 432 out of 450, which is regarded as *high* proficiency in English reading by ETS (Powers, 2010), while the average TOEIC reading scores for the low proficient group was 211 that is categorized as *low* proficiency in English reading. Taken together, I concluded that these participants would be considered as the low and high proficient learners of English. All participants were briefed on the tasks involved and the purpose of the investigation and were asked to participate, and all agreed. They received course credit for completing the activities.

### 3.2.4.2 Material

The reading passages used in this present study includes one set of texts that consists of an expository text and a narrative text, *The Circulatory System*, adopted from the pilot Study #2 (Clariana et al., 2014; originally from Wolfe & Mienko, 2007). In the two studies, the set of texts was successfully used to reveal the influence of text genres on reading comprehension, or readers’ KS, in *L1 reading contexts*.

The expository text was designed to present the basic factual information about the human circulatory system, where the information was presented in the spatial/temporal/causal order that it exists in the body. Starting at the left ventricle, the text described the path of blood out to the body through the blood vessels, back to the heart and out to the lungs and back. This expository text was 26 sentences with 366 words, 91 content elements and a Flesch grade level score of 7.6. The narrative text is a story about a man, named Alex, who built a machine to shrink himself and ended up being sucked into a man’s body. Alex travelled through the circulatory system, and factual information about the anatomy and the function of the circulatory system was presented along with the narrative elements. The text was 27 sentences long with 378 words, 106 individual content elements and a Flesch grade level score of 6.7. In the science text classification scheme of Goldman and Bisanz
(2002), the two texts fall under the classification ‘textbook’ because they presented basic factual content to the reader and were designed to convey that content.

The set of expository and narrative texts are controlled to contain the same factual information about the content, *The Circulatory System*, and are similar in length and in lexical and syntactic complexity to each other (see Wolfe et al., 2007 for detail and Appendix C for the text materials). As pointed out in the literature review, it may not be possible to draw precise conclusions about the influence of text genres on reading comprehension when contents are not controlled across genre. In addition, it is expected that this text topic, *The Circulatory System*, is very familiar to the participants because the circulatory system is a common school topic. Thus, participants’ Korean or English pre-reading tasks could provide a measure of their prior knowledge.

Taken together, the two texts fit well to understand the relationships between prior knowledge and text genre (related to question 1), as well as between text genres and L2 reading comprehension (related to question 2).

### 3.2.4.3 Procedure

A similar procedure used in the pilot study #1 (Kim, 2017), as described in section 3.1.2, were used in the present study. In brief, (1) all participants were randomly assigned to eight experimental groups which received different pre-to-post reading treatments (n=272, 34 per condition for the high proficiency; n=280, 35 per condition for the low proficiency) and one control group that did not receive any experimental treatment, ONLY read the passage, (n=64, 32 for the high proficiency and 32 for the low proficiency) (see Figure 14).

Next, (2) those in experiment groups performed a pre-reading task (as a sorting task) in Korean or English. For the pre-reading sorting task, the participants were given a paper handout with a list of the 17 key terms from the lesson texts in alphabetical order (either in L1, Korean, or in L2, English depending on treatment) as used in the pilot study #2 (Clariana et al., 2014) and were asked to sort the given key terms to form the “pre-reading KS” based on their innate understanding from the
given key terms (see Appendix B). Then, (3) the participants were given the paper-based lesson text (narrative or expository) and were instructed to ‘read the text as if you are studying for a test’ (see Appendix C). They were allowed to underline or take notes on the text and were allowed 30 minutes to read. After 30 minutes of reading, the instructor collected the lesson text, and (4) participants completed a math task for approximately 5 minutes as a filler task after reading each text and before beginning the post-reading task (see Appendix D). Upon completion of the math problems, (5) they wrote a summary essay from memory as a post-reading task on the given handout (see Appendix E). Participants were instructed that if they could not remember the exact wording of the passage, they should be as close as possible, and they can have as much time as they want for this summary writing. Upon completion, (6) they were asked to complete a multiple-choice posttest which was developed by Wolfe et al. (2007) that consists of selected 10 comprehension-related items (see Appendix F) – the posttest had an acceptable level of internal consistency, as determined by a Cronbach’s alpha of .805. The control participants directly completed the posttest immediately after the completion of the math problems after reading their assigned lesson text.

**Note:** NT indicates narrative text, ET indicates expository text

Figure 14. Research design diagram
Chapter 4

RESULTS

The data for analysis consists of the data arrays of participants’ pre-reading sorting tasks and post-reading essays converted to PFnets and comprehension posttest scores and. Following the pilot study #1 (Kim, 2017), PFnet data are described and compared in four ways including Similarity of PFnets: (1) between pre-reading KS and text genre and (2) between text genre and post-reading KS, and Centrality of PFnets as an alternative holistic measure of PFnets: (3) node centrality and 4) graph centrality.

4.2. Similarity of PFnets

4.2.1. Question 1: The relation between pre-reading KS and text genre

It is possible and even likely that readers will have some prior experience with any specific text topic, and this prior knowledge will likely have a ‘downstream’ influence. To consider the downstream influence of the prior knowledge, i.e., the relationship between individual’s KS before and after reading by text genre (respond to Question 1), the first analysis examined the similarity between each reader’s pre-to-post reading KSs as PFnets by text genre. I expect that since the lesson text, The Circulatory System, and its selected key term are probably familiar to the readers, a reader’s L1 or L2 pre-sorting maps could provide a measure of their L1 or L2 pre-reading KS, while L1 or L2 post-reading essays could provide a measure of the influence of the L2 text passage on their post-reading L1 or L2 KS. Therefore, it is expected that this first analysis can reveal the interaction between pre-reading KS and text genre to support comprehension by comparing pre-to-post KS patterns within the same readers by text genre, i.e., continuance of prior KS or else integration of the text KS – there is very little literature of how text genre interacts with prior knowledge in L2 reading (Foss, 2009).
Data for analysis consists of the two pre-to-post PFnets completed by every participant, one before and one after reading each text genre. The similarities of each student’s pre-reading PFnet with their post-reading PFnet were calculated as links in common (the interaction of PFnets) and as average percent overlap (the average of the interaction), following the approach used in the pilot study #2 (Clariana et al., 2014). Note that the average percent overlap is calculated by dividing the number of common links by the average number of links in both PFnets. These pre-to-post similarity values, one from each student, were averaged together within groups to have an average pre-to-post group average. This within-student analysis was applied to all eight treatments by proficiency level. The descriptive results are summarized in Table 5 and follow-up post hoc pairwise comparisons between treatments are presented in Table 6.

Table 5. Within-student pre-to-post PFnet percent overlap and standard deviations (in parenthesis) with Cohen’s effect size d (using pooled standard deviation) for each treatment in both high proficiency and low proficiency groups.

<table>
<thead>
<tr>
<th></th>
<th>Low Proficiency</th>
<th>High Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marginal mean</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td>NT</td>
<td>ET</td>
</tr>
<tr>
<td>Post-K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-to-K</td>
<td>13 %</td>
<td>31 %</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>E-to-K</td>
<td>11 %</td>
<td>36 %</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>Post-E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-to-E</td>
<td>65 %</td>
<td>85 %</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>E-to-E</td>
<td>59 %</td>
<td>81 %</td>
</tr>
<tr>
<td></td>
<td>(0.18)</td>
<td>(0.26)</td>
</tr>
<tr>
<td>Marginal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
Table 6. Pairwise comparisons between the eight treatment means at each proficiency level, ordered from greatest to least.

<table>
<thead>
<tr>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>[(K-ET-E)=(E-ET-E)=(K-ET-K)=(E-ET-K)] &gt; [(K-NT-E)=(E-NT-E)=(K-NT-K)=(E-NT-K)]</td>
</tr>
</tbody>
</table>

Note: the significant difference columns present the statistically significant differences between the means by treatments from Tukey post hoc test. For example, [(K-ET-E) = (E-ET-E)] > [(K-NT-E) = (E-NT-E)] indicates that the mean for the (K-NT-E) group does not differ from that of the (E-NT-E) group, while both of these means are significantly lower than the means for the (K-ET-E) and (E-ET-E) groups.

For the low proficiency participants, their data set shows a strong relationship between pre-to-post KS compared to the high proficiency participants. The low proficiency participants’ average pre-to-post percent overlap values range from 11% to 85%, while the high proficiency participants’ average pre-to-post percent overlap values range from 11% to 27%. In terms of task language, a conspicuous difference in the low proficiency data set is the strong pre-to-post KS relationship when an L2 (English) was used for the post-reading essay task compared to when an L1 (Korean) was used for the post-reading essay task (mean = 72% vs. 23% of L1 post-reading task, effect size $d = 1.32$, $p < 0.01$). In terms of text genre, an interesting difference to emerge from the low proficiency data is the strong pre-to-post KS relationship in the expository text than in the narrative text (mean = 58% vs. 37% of narrative text, effect size $d = 0.65$, $p = 0.02$), reading the narrative text influenced post-reading KS relatively more (e.g., more change = post KS relatively more different than pre KS) than did reading the expository text (e.g., less change = post KS relatively more like pre KS).

The low proficiency participants’ within-student pre-to-post KS analysis indicates that their prior knowledge is utilized differently by task language (strong pre-to-post KS relationship in the L2) and by text genre (strong pre-to-post KS relationship in the expository text), i.e., the low proficiency participants seem to draw on their prior knowledge more for the L2 summary writing post task (than the L1 summary writing post task) and in summary writing of the expository lesson text (than the narrative lesson text).
For the high proficiency participants, in terms of task language, their data show the small values of overlap between the pre-to-post KS, regardless of which language is used for their post task (mean = 20% vs. 19% of L2 post-reading task). Interestingly, in terms of text genre, their data show a relatively strong pre-to-post KS relationship in the expository text compared to the narrative text (mean = 25% vs. 13% of narrative text, effect size $d = 0.49$, $p = 0.03$), as with the low-proficiency participants, the expository text altered post-reading KS less than did the narrative.

The high proficiency participants’ within-student pre-to-post KS analysis indicates that their prior knowledge is utilized differently by text genre (strong pre-to-post relationship in the expository text) but not by task language (no significant pre-to-post relationship in task language), i.e., the high proficiency participants seem to draw on their prior knowledge more when summarizing the expository text (than the narrative text), but equally for both languages.

4.2.2. Question 2: The relation between text genre and post-reading KS

I examined the influence of narrative and expository texts in terms of both memory for text information and learning from text information (Kintsch, 1994). Memory refers to reproducing and paraphrasing information, and is often assessed with methods such as a free recall summary writing. Learning refers to changes in the reader’s knowledge about a topic, and is often assessed with pre- and post-tests to determine knowledge improvement or with inference questions that cannot be answered directly from the text content (Kintsch, 1994). In the current investigation, memory was measured as summary essays and learning as comprehension posttest.

4.2.2.1. Memory

To consider the influence of reading the text passage on memory by text genre, the second analysis examined the similarity between the lesson text students read and the summary essays students wrote by text genre (i.e., referred to as text-to-essay PFnet similarity). It is expected that this
second analysis can reveal the interaction between text genre and post-reading KS reflected in essays that are triggered by text genre by comparing text-to-essay KS patterns within the same readers—there is very little literature of how text genre influences text memory in L2 reading, as explained at literature section.

Data for analysis consists of the narrative and the expository lesson texts’ PFnets and each student’s essay PFnet. Using the same approach described for pre-to-post KS analysis above, links in common (the intersection of PFnets) and average percent overlap (the average of the intersection) were calculated as the similarity of text-to-essay KS. These text-to-essay similarity values, one from each student, were averaged together to have an average text-to-essay group average. This within-student analysis was applied to all eight treatments by proficiency level. The descriptive results are summarized in Table 7 and follow-up post hoc pairwise comparisons between treatments are presented in Table 8.

The convergent criterion-related validity measures of students’ essay PFnets were estimated using Pearson correlation by comparing the essay PFnet similarity values (i.e., as links in common with the two lesson texts’ PFnets) to human-rater measures of the essays (criterion benchmarks); the human raters were three Korean biology instructors at the Korean University and three American biology graduate students at the Pennsylvania State University. Note that Pearson correlation between two Korean raters’ ratings was \( r = .869 \) \( (p < .001) \) for the narrative essays and \( r = .917 \) \( (p < .001) \) for the expository essays. Pearson correlation between two American raters’ ratings was \( r = .821 \) \( (p < .003) \) for the narrative essays and \( r = .894 \) \( (p < .000) \) for the expository essays. When scores varied by 2 points or less, the mean was used as the human rater’s score. When scores varied by more than 2 points, the essay was reviewed by a third rater and the mean of the three was used as the human rater’s score. In summary, the essay PFnet data showed high criterion-related validity.
Table 7. Within-student lesson texts-to-essays \textit{PFnet} percent overlap and standard deviations (in parenthesis) with Cohen’s effect size \(d\) (using pooled standard deviation) for each treatment in both high proficiency and low proficiency groups.

<table>
<thead>
<tr>
<th></th>
<th>Low Proficiency</th>
<th></th>
<th>High Proficiency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(NT)</td>
<td>(ET)</td>
<td>Marginal mean (d)</td>
<td>(NT)</td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>\text{Post-K}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(K\rightarrow K)</td>
<td>59 (%)</td>
<td>56 (%)</td>
<td>(0.15) (%)</td>
<td>69 (%)</td>
</tr>
<tr>
<td>(E\rightarrow K)</td>
<td>61 (%)</td>
<td>62 (%)</td>
<td>52 (%) (0.15)</td>
<td>61 (%)</td>
</tr>
<tr>
<td>\text{Post-E}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(K\rightarrow E)</td>
<td>33 (%)</td>
<td>29 (%)</td>
<td>(0.10) (%)</td>
<td>65 (%)</td>
</tr>
<tr>
<td>(E\rightarrow E)</td>
<td>34 (%)</td>
<td>31 (%)</td>
<td>30 (%) (0.27)</td>
<td>64 (%)</td>
</tr>
<tr>
<td>\text{Marginal mean}</td>
<td>46 (%)</td>
<td>35 (%)</td>
<td>(0.18) (%)</td>
<td>64 (%)</td>
</tr>
<tr>
<td>(d)</td>
<td>0.79*</td>
<td></td>
<td></td>
<td>0.93*</td>
</tr>
</tbody>
</table>

* \(p < .05\)

Table 8. Pairwise comparisons between the eight treatment means at each proficiency level, ordered from greatest to least.

<table>
<thead>
<tr>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low ([\langle K\rightarrow NT\rangle]=\langle E\rightarrow NT\rangle\rangle &gt; \langle K\rightarrow ET\rangle=\langle E\rightarrow ET\rangle &gt; \langle K\rightarrow NT\rangle=\langle E\rightarrow NT\rangle\rangle &gt; \langle K\rightarrow ET\rangle=\langle E\rightarrow ET\rangle\rangle</td>
</tr>
<tr>
<td>High ([\langle K\rightarrow ET\rangle=\langle E\rightarrow ET\rangle=\langle K\rightarrow NT\rangle=\langle E\rightarrow NT\rangle\rangle &gt; \langle K\rightarrow NT\rangle=\langle E\rightarrow NT\rangle=\langle K\rightarrow ET\rangle=\langle E\rightarrow ET\rangle\rangle</td>
</tr>
</tbody>
</table>

Note: the significant difference columns present the statistically significant differences between the means by treatments from Tukey post hoc test.

For the low proficiency participants, as expected, their data shows a weak text-to-essay KS relationship compared to the high proficiency participants (i.e., their essays were less like the lesson text). The low proficiency participants’ average text-to-essay percent overlap values range from 29\% to 62\%, while the high proficiency participants’ average text-to-essay percent overlap values range from 61\% to 85\%. However, in terms of task language, a conspicuous difference in the low proficiency data set is a relatively strong text-to-essay KS relationship when an L1 was used for the post-reading essay task compared to when L2 was used for the post-reading essay task (mean = 52\% vs. 30\% of an L2 post-reading task, effect size \(d = 0.88, p = 0.001\)), the L1 post-reading KSs reflected
in the summary essays had more similar KS with the lesson text they read than the L2 post-reading KSs. In terms of text genre, an interesting finding from the low proficiency participants is that there was a difference between narrative and expository texts for the text-to-essay KS relationship (to the narrative text mean = 46% vs. 35% to the expository text, effect size $d = 0.79$, $p = 0.01$), the post-reading essay KSs are more similar with the lesson text KS when reading the narrative lesson text than the expository lesson text.

The low proficiency participants’ within-student text-to-essay KS analysis indicates that their post-reading KS was more like the lesson text KS they read when an L1 was used for the post-reading essay task compared to when L2 was used, and also when reading the narrative text than when reading the expository text, i.e., thus the memory of the lesson texts (measured as their text-to-essay PFnet similarity) differs depending on task language and on text genre for these low proficiency participants.

For the high proficiency participants, their data shows a strong text-to-essay KS relationship, relative to the low proficiency participants (i.e., their essays were more like the lesson text). In terms of task language, as expected, there was no difference between the languages for the post-reading essay task for their text-to-essay KS relationship ($p = .89$), post-reading essay KSs in both languages had a similar KS with the lesson texts. However, in terms of text genre, there was a difference between narrative and expository texts for the text-to-essay KS relationship (to expository text mean = 81% vs. 64% to the narrative text, effect size $d = 0.93$, $p = 0.00$), the post-reading essay KSs are more similar with the lesson text KS when reading the expository lesson text than the narrative lesson text; note that this is the opposite pattern of what was reported above for low proficiency participants.

The high proficiency participants’ within-student text-to-essay KS analysis indicates that their post-reading KS was like the lesson text KS they read regardless of which language was used for their post-reading task, but more like the lesson text KS when reading the expository text than reading the narrative text, i.e., the memory of the lesson texts (measured as their text-to-essay PFnet similarity) may differ depending on text genre, but not on task language for this high proficiency participants.
4.2.2.2. Comprehension Posttest

To consider the influence of reading the text passage on traditional measures of learning by text genre, a three-way ANOVA was conducted to determine the effects of task language (write the essay in an L1 or L2), proficiency level (Low or High), and text genre (Expository or Narrative) on learning as the comprehension posttest. Comprehension posttests were normally distributed ($p > .05$), as assessed by Shapiro-Wilk’s test of normality. There was homogeneity of variances, as assessed by Levene’s test for equality of variances ($p = .994$). A standard alpha level of .05 was used to test for statistical significance in all analysis in this present investigation. The descriptive statistics of the posttest are presented in Table 9.

Table 9. Means and standard deviations for comprehension posttest scores (max. 10), essay PFnet similarity to the lesson text as Sim to Text and to the individual Posttest as Sim to Posttest, and Graph Centrality (C\text{graph}, a measure of KS form).

<table>
<thead>
<tr>
<th></th>
<th>Narrative Text</th>
<th></th>
<th>Expository Text</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1 essay</td>
<td>L2 essay</td>
<td>None</td>
<td>L1 essay</td>
<td>L2 essay</td>
<td>None</td>
</tr>
<tr>
<td>MC Posttest</td>
<td>5.9 (1.29)</td>
<td>2.8 (0.78)</td>
<td>3.7 (1.12)</td>
<td>4.7 (1.52)</td>
<td>2.9 (1.07)</td>
<td>3.0 (1.01)</td>
</tr>
<tr>
<td>Sim to Text</td>
<td>0.57</td>
<td>0.39</td>
<td>--</td>
<td>0.50</td>
<td>0.28</td>
<td>--</td>
</tr>
<tr>
<td>Sim to Posttest</td>
<td>0.55</td>
<td>0.20</td>
<td>--</td>
<td>0.53</td>
<td>0.11</td>
<td>--</td>
</tr>
<tr>
<td>C\text{graph}</td>
<td>linear</td>
<td>hierarchical</td>
<td>--</td>
<td>hierarchical</td>
<td>linear or network</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Narrative Text</th>
<th></th>
<th>Expository Text</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1 essay</td>
<td>L2 essay</td>
<td>None</td>
<td>L1 essay</td>
<td>L2 essay</td>
<td>None</td>
</tr>
<tr>
<td>MC Posttest</td>
<td>8.4 (1.41)</td>
<td>8.3 (1.98)</td>
<td>7.6 (1.22)</td>
<td>8.6 (2.00)</td>
<td>8.7 (1.51)</td>
<td>7.3 (1.35)</td>
</tr>
<tr>
<td>Sim to Text</td>
<td>0.72</td>
<td>0.69</td>
<td>--</td>
<td>0.76</td>
<td>0.73</td>
<td>--</td>
</tr>
<tr>
<td>Sim to Posttest</td>
<td>0.69</td>
<td>0.65</td>
<td>--</td>
<td>0.70</td>
<td>0.66</td>
<td>--</td>
</tr>
<tr>
<td>C\text{graph}</td>
<td>hierarchical</td>
<td>linear</td>
<td>--</td>
<td>hierarchical</td>
<td>hierarchical</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: NT C\text{graph} = linear, ET C\text{graph} = hierarchical; None = control group (reading + posttest)
There was a significant three-way interaction between essay task language, proficiency level, and lesson text genre, $F(2, 60) = 7.406, p = .001$, partial $\eta^2 = .58$. There was a significant simple two-way interaction between text genre and task language for low proficiency, $F(2, 60) = 5.252, p = .008$, partial $\eta^2 = .88$, but not for high proficiency, $F(2, 60) = 2.868, p = .065$. There was a significant simple main effect of text genre for the low proficiency when the L1 was used for their post-reading task, $F(2, 60) = 14.766, p < .0005$, partial $\eta^2 = .42$, but not when L2 was used, $F(2, 60) = 0.660, p = .521$. The significant interaction is shown in Figure 15. Cohen effect size are, $d = \text{Low } [(K-ET-E) = (E-ET-E) = (K-NT-E) = (E-NT-E) = (NoET)] < \text{Low } (NoNT) < \text{Low } [(K-ET-K) = (E-ET-K)] < \text{Low } [(K-NT-K) = (E-NT-K)] < \text{High } [(NoNT) = (NoET)] < \text{High } [(K-ET-E) = (E-ET-E) = (K-NT-K) = (K-NT-E) = (E-NT-K) = (E-NT-E)]; E \text{ English as an L2, K Korean as an L1, NT narrative text, ET expository text (e.g., K-NT-E: sort Korean - read narrative text - write English); No none reading activity (e.g., NoNT: no sorting task - read narrative text - no essay task).}

Further, multiple regression analysis was used to test if the post-reading task language and text genre significantly predict students’ comprehension posttest performance by proficiency level. There was linearity as assessed by partial regression plots and a plot of studentized residuals against

![Figure 15](image.png)

Figure 15. The comprehension posttest two-way interaction of essay language and text genre for both low proficiency and high proficiency. The averages for Low-control and High-control are shown.
the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.910. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. There assumption of normality was met, as assessed by Q-Q Plot. The results of the regression indicated that task language and text genre explained 76.4% of the variance of the comprehension posttest score for the low proficiency participants, $F(2,102) = 152.49, p < .001$, adj. $R^2 = .764$, but not for the high proficiency participants, $F(2,95) = 32.393, p < .145$. Further, considering both low and high proficiency learners, it was found that essay similarity to lesson text ($\beta = .51, p < .001$) and also to graph centrality ($\beta = .36, p < .001$) significantly predicted comprehension posttest for the low proficiency participants, as well as for the high proficiency participants ($\beta = .65, p < .001$, for essay similarity to lesson text, $\beta = .39, p < .001$, for graph centrality).

In sum, for the low proficiency participants, they were sensitive to text genre and task language for learning of text content; they scored significantly higher on posttest in the narrative text than the expository text (mean = 4.1 vs. 3.3 of the expository, effect size $d = 0.65, p = 0.01$) and in an L1 task than in an L2 task (mean = 5.0 vs. 2.9 of the L2 task, effect size $d = 1.15, p = 0.000$). For the high proficiency participants, they were not sensitive to text genre and task language for learning of text content, i.e., their L2 comprehension did not differ as functions of text genre and task language.

### 4.2.3. Summary of PFnet similarity

The PFnet similarity results showed the different relationships between prior knowledge and text genre (Question 1) and between text genre and memory and learning (Question 2) by proficiency level. Table 10 provides a summary of the similarity results.
Table 10. Summary of results above for the pre-to-post and text-to-essay PFnet similarity results.

<table>
<thead>
<tr>
<th></th>
<th>Pre-to-Post</th>
<th>Text-to-Essay (memory)</th>
<th>Posttest (learning)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task language</td>
<td>Text genre</td>
<td>Task language</td>
</tr>
<tr>
<td>Low</td>
<td>L2 &gt; L1</td>
<td>ET &gt; NT</td>
<td>L1 &gt; L2</td>
</tr>
<tr>
<td>High</td>
<td>L1 = L2</td>
<td>ET &gt; NT</td>
<td>L1 = L2</td>
</tr>
</tbody>
</table>

4.3. Centrality of PFnets

4.3.1. Graph Centrality

Graph centrality ($C_{graph}$) operationalized by Clarina et al. (2011) is a numerical measure of a network graph form, or structure, that ranges from zero (linear structure, < .4) to one (star structure, > .7), with mid-range values (from 0.4 to 0.6) indicating optimally relational structures, as explained in detail in section 2.3.3.2.

For the low proficiency participants (see Figure 16), in the narrative text condition, their L1 pre-reading (sorting task) KSs had a relational network structure (perhaps due to a non-appropriate dominance of the structure by some terms and relationships) while the L2 pre-reading KSs had a linear structure (perhaps a deficient structure). However, their L1 post-reading (essay) KSs had a somewhat linear structure ($C_{graph} = 0.31$ to $0.35$, respectively) more like the narrative lesson text KS centrality form ($C_{graph} = 0.32$), relative to their L2 post-reading KSs ($C_{graph} = 0.53$ to $0.55$, respectively) that had a more hierarchical structure. In the expository text condition, as with the narrative text, their L1 pre-reading KSs had a relational network structure (perhaps an inappropriately complicated structure) while the L2 pre-reading KSs had a linear structure (perhaps somewhat deficient structure). However, their L1 post-reading KSs had a hierarchical structure ($C_{graph} = 0.49$ to $0.52$, respectively) more like the expository lesson text KS ($C_{graph} = 0.42$), relative to their L2 post-reading KS ($C_{graph} = 0.20$ to $0.63$, respectively) that had linear to network structures.
It is interesting to note that the narrative L1 post-reading (essay) KSs were more similar to the narrative lesson text KS (0.31 to 0.35 vs. 0.32 of NT) than were the expository L1 post-reading (essay) KSs to the expository lesson text KS (0.49 to 0.52 vs. 0.42 of ET), i.e., a stronger text-to-essay KS ‘form’ similarity in the narrative text, as evidenced by the text-to-essay PFnet similarity above. However, the expository L2 post-reading KSs were more similar to their pre-reading KSs (network to network, linear to linear) than were the narrative L2 post-reading KSs to their pre-reading KSs.
(network to hierarchical, linear to hierarchical), i.e., a stronger pre-to-post KS ‘form’ similarity in the expository text, as evidenced by the pre-to-post PFnet similarity above.

These results for graph centralities (as an overall measure of PFnet KS ‘form’) for the low proficiency participants support the findings from the similarity of PFnets as reported in section 4.2; the low proficiency participants had a stronger pre-to-post KS similarity in L2 task than in the L1 task, especially in the expository text (refer back to Tables 5 and 6), higher text-to-essay KS similarity in the L1 task than in the L2 task, especially in the narrative text (refer back to Tables 7 and 8), and further higher comprehension posttext scores after the L1 task than after the L2 task, especially in the narrative text (refer back to Table 9).

For the high proficiency participants (see Figure 16), their pre-reading KSs had a relational network structure (perhaps an inappropriately complicated structure) in both task languages and in both text genres. However, in the expository condition, their post-reading KSs in both languages had hierarchical structures ($C_{graph} = 0.46, 0.43, 0.45, 0.43$, respectively) more like the expository lesson text KS ($C_{graph} = 0.42$), but interestingly, in the narrative condition, their post-reading KSs in both languages had linear-to-hierarchical structures ($C_{graph} = 0.43, 0.37, 0.40, 0.38$, respectively) like and unlike the narrative lesson text KS ($C_{graph} = 0.32$) that had a somewhat linear structure, their narrative post-reading KSs were close to a hierarchical structure more like the expository lesson text KS (refer back to Table 5 for a summary).

It is also interesting to note that the expository post-reading KSs were more similar to the expository lesson text KS (0.43 to 0.46 vs. 0.42 of ET) than were the narrative post-reading KSs to the narrative lesson text KS (0.37 to 0.43 vs. 0.32 of NT), i.e., a stronger text-to-essay KS ‘form’ relationship in the expository text, as also evidenced by their text-to-essay PFnet similarity above. Also, the expository post-reading KS forms were more similar to their pre-reading KS forms (network to hierarchical) than were the narrative post-reading KSs to their pre-reading KSs (network to linear or hierarchical), i.e., a stronger pre-to-post KS ‘form’ relationship in the expository text, as evidenced by their pre-to-post PFnet similarity above.
These findings for graph centralities (as an overall measure of *PFnet KS* ‘form’) for the high proficiency participants visually describe the findings for the similarity of *PFnets* as reported at 4.2; the high proficiency participants had relatively stronger pre-to-post KS relationship in the expository text than in the narrative text (refer back to Tables 5 and 6), and they had higher text-to-essay similarity in the expository text than in the narrative text (refer back to Tables 7 and 8).

4.3.2. Node Centrality

Following the pilot study #1 approach (Kim, 2017), I used Proxscal multidimensional scaling (SPSS 20.0) to visually represent each *PFnet* as an individual point in a 2-dimensional space by using the *node degree vectors* used above to calculate graph centrality (see 2.3.3.2 section for detail). Note that the *KNOT* software tool was used to average together individual *PFnet* proximity data within each treatment to establish a single group average *PFnet* and its average node centrality. Also note that short vectors in the MDS figure indicate small pre-to-post change while long vectors indicate larger pre-to-post change; also nearness in the MDS space indicates similarity. In the multidimensional scaling (MDS) figure, the narrative lesson text KS (NT) fell toward the left of the MDS figure and the expository lesson text KS (ET) toward the top left of the figure. The dimensional representations in both figures show a transformation of average group KS measured as node centrality from pre-to-post-reading *PFnets*. 
Figure 17. ‘Group-level’ proxsca 2-dimensional representation of the PFnet node centrality data of the narrative text (left) and expository text (right) from pre-to-post for the eight treatment conditions.

For the low proficiency participants (dash line), since only L1 post-reading KSs (Post_K) in both text genres are towards the lesson text KS (either NT or ET), I infer from the diagrams that their L1 post-reading KSs in both text genres converged more with the lesson text KS (note: convergence is represented as nearness in the MDS) while their L2 post-reading KSs are towards the right of the figure, away from the lesson text KS with no clear convergence, i.e., a stronger post-reading KS convergence with the lesson text in the L1 task in both text genres. For the high proficiency participants (solid line), since all L1 and L2 post-reading KSs (Post_K & Post_E) in both text genres ‘moved’ very close to the lesson text KS (either NT or ET), I infer that their post-reading KSs in both languages and in both text genres converged with the lesson text KSs, i.e., a strong post-reading KS convergence with the lesson text in both task languages and in both text genres.

Interestingly, the pre-to-post length of arrows could suggest the amount of pre-to-post KS changes over time. For the low proficiency participants, they had long pre-to-post arrows in the L1 task in both text genres compared to the L2 task that had short pre-to-post arrows. It could be assumed...
that their KSs were changed toward the lesson text KS (either NT or ET) in the L1 task than in the L2 task regardless of which text was read, i.e., their L1 post-reading KSs are similar with the lesson text KS while their L2 post-reading KS are still similar with their pre-reading KS. For the high proficiency participants, since they had long pre-to-post arrows in both task languages and in both text genres, it could be assumed that their KSs were considerably changed toward the lesson text KS after reading the lesson texts regardless of which text was read and which language was used.

Thus, this MDS node degree vector analysis for both high and low proficiency participants visually depicts the PFnet similarity results above; first, for the low proficiency participants, why they had a stronger pre-to-post KS relationship in the L2 task than in the L1 task (refer back to Tables 5 and 6), why they had a stronger text-to-essay KS relationship in the L1 task than in the L2 task (refer back to Tables 7 and 8) and so had higher comprehension posttext scores in the L1 task than in the L2 task (refer back to Table 9); second, for the high proficiency participants, why they had a weaker pre-to-post KS relationship in both task languages and in both text genres (refer back to Tables 5 and 6), but had a strong text-to-essay KS relationship in both task languages and in both text genres (refer back to Tables 8 and 9) and so had higher comprehension posttext scores in both task languages and in both text genre (refer back to Table 9).

### 4.4 Summary of results

In chapter 4, research hypotheses were tested to investigate the relationships between pre-reading KS and text genre (research question 1) and between text genre and post-reading KS (‘memory’ for research question 2-1) and text comprehension (‘learning’ for research question 2-2). Table 11 provides a summary of the research hypotheses and corresponding results.
Table 11. Summary of the results

**Question 1: The relation of pre-reading KS and text genre**

<table>
<thead>
<tr>
<th>Task language (L)</th>
<th>Text genre (T)</th>
<th>Task language (L)</th>
<th>Text genre (T)</th>
<th>Results</th>
</tr>
</thead>
</table>
| Low L2 > L1       | NT > ET        | L2 > L1           | ET > NT        | • Hypothesis of relying more on prior knowledge in the L2 task *was supported*  
|                   |                |                   |                | • Hypothesis of relying more on prior knowledge in the narrative text *was not supported*  |
| High L1 = L2      | NT > ET        | L1 = L2           | ET > NT        | • Hypothesis of relying less on prior knowledge in both task languages *was supported*  
|                   |                |                   |                | • Hypothesis of relying more on prior knowledge in the narrative text *was not supported*  |

**Question 2: The relation of text genre and post-reading KS**

*Memory* (measured as text-to-essay KS similarity)

<table>
<thead>
<tr>
<th>Task language (L)</th>
<th>Text genre (T)</th>
<th>Task language (L)</th>
<th>Text genre (T)</th>
<th>Results</th>
</tr>
</thead>
</table>
| Low L1 > L2       | NT > ET        | L1 > L2           | NT > ET        | • Hypothesis of better memory in the L1 task *was supported*  
|                   |                |                   |                | • Hypothesis of better memory in the narrative text *was supported*  |
| High L1 = L2      | NT > ET        | L1 = L2           | ET > NT        | • Hypothesis of no memory difference from task language *was supported*  
|                   |                |                   |                | • Hypothesis of better memory in the narrative text *was not supported*  |
Learning (measured as comprehension posttest)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task Language</strong></td>
<td><strong>Text Genre</strong></td>
</tr>
<tr>
<td>Low</td>
<td>L1 &gt; L2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>L1 = L2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 5

DISCUSSION AND IMPLICATIONS

5.1 Introduction

In this chapter I will discuss the results reported in Chapter 4 as they relate to the research questions investigated in this current study. For each research question, I will summarize and discuss the results as well as their theoretical implications. Finally, I will discuss the study’s limitations and make recommendations for future research.

5.2 Research Question 1: The relation between pre-reading KS and text genre

The first research question inquired about the contribution of pre-reading KS to post-reading KS by text genre. For task language, as hypothesized, this investigation demonstrated that the effect of prior knowledge on post-reading KS was far greater in the L2 essay task than in the L1 essay task for the low proficiency participants, but there was no difference for the high proficiency participants. For text genre, contrary to expectations, this investigation demonstrated that the effect of prior knowledge on post-reading KS was far greater in the expository text than the narrative text for both proficiency groups.

5.2.1 Low proficiency readers

The low proficiency participants’ pre-to-post PFnet similarity values indicate that their post-reading KSs (i.e., memory as free recall summary essays) were more like their pre-reading KSs in the L2 task than the L1 task (72% vs. 23% pre-to-post overlap of the L1, \(d = 1.32\)) and in the expository text than the narrative text (58% vs. 37% pre-to-post overlap of the narrative, \(d = 0.65\); refer back to Tables 5 and 6). In addition, the graph and node centrality values visually support their pre-to-post
*PFnet* similarity results. First, the graph centrality results show that the low proficiency participants had a fairly idiosyncratic (perhaps inappropriately complicated or deficient) pre-reading KS ‘form’ in both text genres and in both task languages and these inappropriately structured pre-reading KSs largely transferred to their post-reading KSs in the L2 task and in the expository text (see Figure 16). Second, the node centrality values displayed as MDS figure also shows the small amount of pre-to-post KS changes in the L2 task while the large amount of pre-to-post KS changes in the L1 task, although the MDS figures did not show the pre-to-post KS changes by text genre (see Figure 17).

These findings from the similarity and centrality of the low proficiency participants indicate that the low proficiency participants seem to draw more on their prior knowledge for the L2 task than for the L1 task and for the expository lesson text than for the narrative lesson text. For essay task language, as hypothesized, the low proficiency participants relied more on prior knowledge as KS for the L2 task than the L1 task, consistent with pilot studies (Kim & Clariana, 2015, 2016, 2017) and other previous research (e.g., Kroll & Stewart, 1994). For example, this finding could be explained in part by mental lexicon studies (e.g., Kroll & Stewart, 1994) reporting that (mental) translation from an L2 to L1 was ‘lexically’ mediated while only (mental) translation from an L1 to L2 appears to be ‘conceptually’ mediated. Further, if the low proficiency participants have difficulty reading an L2 text, then, they likely revert to mentally using their L1-based prior knowledge for solving the demanding conceptual L2 reading activity, that is, the idiosyncratic but richer L1-based-pre-reading KS could be conceptually used to facilitate the L2 reading – but the language transfer (Lakshmanan, 1994) would have positive or negative influence depending on the quality of their L1-based prior knowledge on the to-be-learned content (see Kim et al., 2015, for example). In terms of the bilingual competition model (Hernandez, Li, & MacWhinney, 2005), this is referred to as a “parasitic” L2 representation; the L2 representation becomes parasitic on the L1 representation, especially for the low proficiency L2 learners (Zhao & Li, 2007) whose L2 is less than adequate for the task.

Further, neurolinguistics findings might also explain the low proficiency participants’ strong dependence on prior knowledge for the L2 tasks. Several studies using fMRI (Chan et al., 2008) found that high proficiency bilinguals deal with word information of the two languages *separately*; whereas,
because low proficiency bilinguals have not yet developed neural sensitivity in their L2, their brain areas for L1 processing can shape the neural representation of L2 (i.e., L2 is not fully separated from an L1, but rather largely overlapped with L1 neuro areas; Yang, Tan, & Li, 2011). This relatively undeveloped L2 neural sensitivity of the low L2 proficiency participants could explain why they follow (or mimic) their idiosyncratic L1-based pre-reading KS when the L2 text was framed by the L2 tasks.

For text genre, the low proficiency participants’ relatively stronger dependence on prior knowledge for the expository text appears to contradict some prior research (in monolingual, native language) that show a prior knowledge advantage for narrative text (e.g., Kuhara-Kojima & Hatano, 1991; Schneider et al., 1989). It is unusual that pre-reading KSs were unrelated to post-reading KSs for those who read the narrative lesson text. But these findings are consistent with the data from previous research using the same set of narrative and expository texts, The Circulatory System, (Wolfe et al., 2005, 2007, 2010; Clariana et al., 2014). For example, Wolfe et al. (2007) reported a different processing focus as a function of text genre in which expository readers are more concerned with integrating the circulatory system content with prior circulatory system knowledge while narrative readers are more concerned with creating a mental representation of the narrative aspects of the text (e.g., events, actions, places, and outcomes in stories). A pilot study #2 (Clariana et al., 2014) reanalyzing Wolfe et al. data (2007) using the KS tools also confirmed the strong relationship between prior knowledge and expository text, suggesting the expository readers focus their processing on integration of the content with prior knowledge to a greater extent than those reading the narrative text.

One possible explanation for this discrepancy is the difference in the extent to which the factual text content is tied to the narrative elements of the text. In previous research, the narrative texts typically described concrete action such as in sport events. When describing a soccer or baseball game, for example, the factual action and the narrative events are likely to be more closely tied together than they are in the current circulatory system texts. The narrative in the current study may be seen as a more ‘artificial’ device for delivering the content, so some of the narrative may be not
necessary to explain the content. Perhaps due to this artificial narrative characteristic of the text in this study, the prior knowledge of the participants is less integrated than in narratives in which the content is more central to the story.

Another possible explanation is that given the low proficiency participants’ high scores on both memory and learning in the narrative than the expository text that will be discussed at the next section, they may take advantage of the narrative cues (e.g., temporal and causal cues) that facilitate comprehension (Kintsch et al., 1984), but in the expository text, they might not be able to enjoy such cues (perhaps due to their low proficiency in L2 and/or to the expository genre features) so they should rely more on their idiosyncratic pre-reading KS rather than the expository text content. This could explain in part why the low proficiency participants had relatively stronger pre-to-post KS relationship in the expository text than the narrative text.

To sum up, for the low proficiency participants, their post-reading KSs (as essays) were related to prior circulatory system knowledge in the expository text and in the L2 task, suggesting that the low proficiency participants may draw more on their prior knowledge for comprehending the expository text content (than the narrative text content) and to solve the L2 task (relative to the L1 essay production task).

5.2.2 High proficiency readers

The high proficiency participants’ pre-to-post PFnet similarity values indicate that their post-reading KSs (i.e., as essays) were less like their pre-reading KSs in both task languages (only 19-20% pre-to-post overlap) but relatively more like their pre-reading KSs in the expository text than the narrative text (25% vs. 13% pre-to-post overlap of the narrative, $d = 0.49$; refer back to Tables 5 and 6). In addition, the graph and node centrality values visually support their pre-to-post PFnet similarity results. First, the graph centrality results show that the high proficiency participants had a fairly idiosyncratic pre-reading KS ‘form’ in both text genres and in both task languages but these pre-reading KSs were considerably changed after reading in both task languages but less changed in the
expository text than the narrative text (see Figure 16). Second, the node centrality values displayed in the MDS figures also shows the large amount of pre-to-post KS changes in both task languages, although the MDS figures did not show the pre-to-post KS changes by text genre (see Figure 17).

These findings from the network similarity and from the form centrality of the high proficiency participants indicate that the high proficiency participants seem to utilize their prior knowledge differently for each text genre (more for the expository text than the narrative text) but not differently for the task language. For the essay task language, as hypothesized, there was no difference in the pre-to-post PFnet similarity as a function of the task language. Given their high proficiency in both languages, they may be able to build appropriately structured post reading KSs in either language, rather than relying on their idiosyncratic pre-reading KS for the L2 text comprehension as did the low proficiency participants. For example, looking forward to the results in text-to-essay PFnet similarity in the next section, the high proficiency participants’ post-reading KSs were more like the lesson text KS and less like their pre-reading KSs in both task languages. This finding is consistent with several pilot studies with Korean English language learners (Kim & Clariana, 2015, 2016, 2017) and other studies (e.g., Beare & Bourdages, 2007; Cohen & Brooks-Carson, 2001; Friedlander 1990; Wang & Wen, 2002; Woodall, 2002). These studies have shown that low proficient bilinguals tend to rely on their L1 for L2 reading far more than the high proficiency bilinguals, although there are some research with conflict findings (e.g., see Hell & Kroll, 2013, for debate of L1 use). For example, as explained above, pilot Study #1 (Kim, 2017) reported that the high proficiency readers’ post-reading KSs were more correlated with the lesson text KS but less correlated with their pre-reading KS; whereas the low proficiency readers’ post-reading KSs were more related to their pre-reading KS but less related to the lesson text KS, supporting the finding from the current study. Thus, this study provides additional evidence of how prior knowledge plays a different role in how a text is interpreted by proficiency level.

For text genre, as with the low proficiency participants, the high proficiency participants utilized their prior knowledge more for the expository text than the narrative text. Thus, this current finding visually support and extend that from L1 reading into L2 reading, suggesting that readers
(native readers and target language readers) attempt to incorporate text content with prior knowledge to a greater extent while processing expository texts than narrative texts both in L1 and L2 reading. Again, this conclusion should be examined in future research, however, because there are other studies showing the easy integration with prior knowledge in narrative texts (e.g., Kuhara-Kojima et al., 1991; Schneider et al., 1989; Spilich et al., 1979).

To sum up, for the high proficiency participants, their post-reading KSs (as essays) were related to prior circulatory system knowledge in the *expository* text but were unrelated to task language, suggesting that the high proficiency participants may draw more on their prior knowledge when summarizing the expository text content (than the narrative text content) but equally for both languages.

### 5.3 Research Question 2: The relation between text genre and post-reading KS

The second research question considered differences in memory and learning of the L2 text content due to genre (narrative or expository) and how language proficiency modulates the differences. For task language, as hypothesized, this investigation demonstrated that memory and learning of text content were far greater in the *L1* task than in the L2 task for the low proficiency participants but there was no overall difference as a function of task language for the high proficiency participants. For text genre, as hypothesized, this investigation demonstrated that memory and learning of text content were far greater in the *narrative* text than the expository text for the low proficiency participants. However, contrary to expectations, the high proficiency participants performed relatively better on memory in the *expository* text but interestingly there was no difference between genres on learning.
5.3.1 Low proficiency readers

The low proficiency participants’ lesson text-to-essay \textit{PFnet} similarity values indicate that their post-reading KSs (i.e., as essays) were more like the L2 lesson text KS in the \textit{L1} task than the L2 task (52\% vs. 30\% text-to-essay overlap of the L2 task, \(d = 0.88\)) and more with the \textit{narrative} text than the expository text (46\% vs. 35\% text-to-essay overlap of the expository, \(d = 0.79\); refer back to Tables 7 and 8). Accordingly, these text base-like-post-reading KSs had significant relationships with the comprehension posttest in the L1 task (\(r = 0.54, p < .05\)) and in the narrative text (\(r = 0.38, p < .05\)), i.e., better memory (measured as text-to-essay similarity) and learning (measured as posttest score) in the L1 task and in the narrative text (refer back to Table 9). The quality of the structure of their KS correlated with their comprehension posttest scores.

In addition, the graph and node centrality values visually support their text-to-essay \textit{PFnet} similarity results. First, the graph centrality results show that the low proficiency participants’ post-reading KSs had more similar KS form with the lesson text KS in the L1 essay than in the L2 essay and in the narrative text than in the expository text (see Figure 16). Second, the node centrality values displayed as MDS figure also shows a stronger post-reading KS convergence with the lesson text in the L1 essay than in L2 essay, although the MDS figures did not show the text-to-essay KS convergence by text genre (see Figure 17).

These findings from the similarity and centrality of the low proficiency participants indicate that memory and learning of text content were far greater in the \textit{L1} task and in the narrative text. For task language, as hypothesized, the low proficiency participants showed better performances on both memory and learning in the \textit{L1} essay than the L2 essay, consistent with pilot studies (Kim & Clariana, 2015, 2016, 2017) and other previous research (e.g., Duursma et al., 2007; Eisterhold, 1990; O’Malley & Chamot, 1990; Ringbom, 1992) on the benefits of using an \textit{L1} for L2 reading. This finding may be partly explained by the mental lexicon studies and fMRI studies discussed above (section 5.2.1) on the dependence on an \textit{L1} during L2 reading. Also, these \textit{L1} advantages may be explained by the findings from L2 writing studies, reporting that lower proficiency readers rely on
their L1 in order to search out and assess appropriate wording, convey an intended meaning, or compensate for their limited ability to comprehend L2 text content. For example, studies that compared directed summary writing with translated summary writing as post-reading tasks have reported that the low proficiency readers benefited from translating processes from an L1 to L2, in terms of syntactic complexity and better content, style, and organization. A pilot study #4 (Kim & Clariana, 2015) demonstrated that when low proficiency Korean English language readers were required to write a translation summary, then latent (relational) rich L1-based post-reading KSs (from the Korean summary) were positively transferred to their meager (linear) L2-based post-reading KS (to English summary) and this L1-based-L2 KS can positively impact on L2 comprehension posttest scores. Pilot study #1 (Kim, 2017) also showed the positive role of L1 use for the memory and learning of L2 text content (see section 3.1.3). Thus, the findings from the present study add to a growing body of evidence of the positive influence of L1 use in L2 reading for the low proficiency readers.

For text genre, as hypothesized, the low proficiency participants showed better performance on both memory and learning in the narrative text than in the expository text, consistent with prior research in monolingual settings (i.e., native language) reporting the narrative’s benefit for text comprehension (e.g., Graesser et al., 1980; Kintsch et al., 1984; Kozminsky, 1977; Petros et al., 1989; Wolfe, 2005; Zabrucky et al., 1992). For example, Kintsch et al. (1984) and many other researchers argue that narrative text structures promote situation model construction, and therefore comprehension and memory of the text content, because of their richer cohesiveness and temporal and causal cues contained in narratives, as discussed at the literature review. Thus, this present study extends the evidence of the superior comprehensibility of narrative texts into L2 reading, suggesting that narrative texts may be beneficial for the low proficiency L2 readers.

To sum up, for the low proficiency participants, memory and learning for the text content were greater in the L1 task (than the L2 task) and in the narrative text (than the expository text) as expected, indicating that memory and learning of the same text content may differ depending on the task language and the text genre, at least for this low proficiency Korean English language learners.
5.3.2 High proficiency readers

The high proficiency participants’ lesson text-to-essay PFnet similarity values indicate that their post-reading KSs (i.e., as essays) were more like the L2 lesson text KS in the expository text than the narrative text (81% vs. 64% text-to-essay overlap of the narrative, $d = 0.93$), but there was a strong but no difference on KS as a function of task language (73% vs. 72% text-to-essay overlap; refer back to Tables 7 and 8). It was anticipated that learning (measured as posttest score) from the expository readers would be better than the narrative readers because of expository readers’ high memory performance (measured as text-to-essay similarity), but this was not generally observed. Regardless of which lesson text was read, there was no difference between genres on comprehension posttest scores (mean = 8.4 vs. 8.7) and both narrative and expository post-reading KSs had significant relationships with the comprehension posttest scores ($r = 0.67$ vs. 0.68; refer back to Table 9).

In addition, the graph and node centrality values visually support their text-to-essay PFnet similarity results. First, the graph centrality results show that expository readers’ post-reading KSs had hierarchical form like the expository lesson text KS while the narrative readers’ post-reading KSs had weak-to-strong hierarchical form unlike the narrative text KS that had a somewhat linear structure, regardless of which language is used (see Figure 16). Second, the node centrality vectors displayed as points on the MDS figure also shows a strong post-reading KS convergence with the lesson text in both languages, although the MDS did not show the text-to-essay KS convergence by text genre (see Figure 17).

These findings from the similarity and centrality of the high proficiency participants suggest that memory and learning of text content differ by text genre they read but did not differ by task language they used. For task language, as hypothesized, the high proficiency participants showed no difference between task languages on both memory and learning, consistent with pilot studies (Kim et al., 2015, 2016, 2017) and other previous research (e.g., Francis, 2005; Zwann et al., 1998). Given that their word-to-text integration is nearly fully symmetrical in both languages (Perfetti & Stafura,
2014), their similar reading outcomes in both languages might be reasonable. For example, pilot Study #1 (Kim, 2017) visually revealed that the high proficiency Korean English language readers constructed similar post-reading KSs in both task language essays while the low proficiency readers built different post-reading KSs depending on the task language, supporting the findings from the current study. Also, these findings could be explained by cognitive psychology studies (e.g., Francis, 2005; Wang & Wang, 2014; Zwann et al., 1998), which have reported that people use “modality-independent cognitive procedure” to construct mental models; for example, people who read about a certain event in a newspaper produced similar mental models as people who saw the same event on a TV. Likewise, comprehension of a text in a different language will also result in a similar KS because conceptual information is largely shared across two languages, if the readers are balanced bilinguals in the two languages (Francis, 2005). Thus, this study confirms the modality-independent cognitive procedure for the high proficiency participants.

For text genre, contrary to expectations, the high proficiency participants had a better memory (as text-to-essay PFnet similarity) in the expository text than the narrative text but there was no difference between genres for learning (as posttest). With respect to memory, the current finding appears to contradict the finding from the low proficiency in the current study and also other prior research on the memory advantage for narrative texts (e.g., Graesser et al., 1980; Kintsch et al., 1984; Luszcz, 1993; Tun, 1989; Wolfe, 2005; Zabrucky & Moore, 1999). As explained, prior research showed the benefits of narrative texts for memory because of their cohesiveness and temporal and causal cues contained in narratives, and so in the current study the low proficiency participants recalled more in the narrative text than the expository text as expected. This interpretation, however, did not hold when applying to the high proficiency participants. For the high proficiency, memory was greater for the expository texts compared with the narrative readers, i.e., stronger text-to-essay similarity in the expository text (hierarchical-to-hierarchical) but lower text-to-essay similarity in the narrative text (linear-to-hierarchical; 81% vs. 64% text-to-essay overlap of the narrative).

These findings related to text genre, however, are consistent with several studies using the same lesson text material, The Circulatory System, (Wolfe et al., 2005, 2007, 2010; Clariana et al.,
2014). For example, Clariana et al. (2014) also found mismatch between the narrative lesson text and structure of narrative readers’ summary essays (i.e., a lower text-to-essay similarity in the narrative). In that study, they expected that students’ essay KS would overlap most with the lesson text KS they read (e.g., expository-to-expository, narrative-to-narrative) but this was not observed in the narrative text for the monolingual college readers. The essay PFnets of the narrative readers on average were more like the expository text PFnet than like the narrative text PFnet, as in the current study. They interpreted the mismatch as indicating post-reading competition between pre-reading KS and text KS. Since the circulatory system topic is often studied in textbooks in an expository form, the participants would have “expository like” pre-reading KS on the topic and this preexisting “expository like” KS may be consolidated through the expository lesson text that could lead to the stronger text-to-essay similarity, while the preexisting “expository like” KS may compete with the KS engendered by the narrative text that could result in the relatively weaker text-to-essay similarity. The graph centrality measures used in this current study support this interpretation by visually revealing that all the high proficiency participants’ pre-reading KS were idiosyncratic but highly relational structure so these inappropriately structured relational KS may create a conflict with the narrative text that had a linear structure.

Then, why didn’t this mismatch happen to the low proficiency participants? One possible explanation of this difference between low and high proficiency for the narrative text is that, according to the graph centrality measures, the low proficiency participants had idiosyncratic but relational pre-reading KSs in an L1 but had loosely linked linear pre-reading KSs in L2 unlike the high proficiency participants that had highly relational (but idiosyncratic) pre-reading KSs in both languages. Then, their “expository like” pre-reading KS would be probably weak in an L2, and in the L2 case there might not be a strong competition between the “expository like” pre-reading KS and the narrative text, so the low proficiency participants could more lean on the narrative text content for the narrative text comprehension that would lead to their relatively stronger narrative text-to-essay similarity than in the high proficiency case.
With respect to reading comprehension scores, unexpectedly, there was no difference between text genres, although the expository readers showed better memory performance than the narrative readers. However, this unexpected finding aligns with some prior studies in which text content is controlled across genre. The majority of the text genre research showing the narrative advantages for comprehension, discussed at the literature review, did not control the content across genres. When content is controlled across genre as in this study, however, the results are mixed with respect to learning advantages. For example, some researchers found that comprehension of text content was better for expository texts than for narrative texts (e.g., Alvermann, Hynd, & Qian, 1995; Hartley, 1986) while others reported no difference between narrative and expository genres (e.g., Cunningham & Gall, 1990; Kintsch et al., 1984) or better for narrative texts (e.g., Graesser et al., 1980). Thus, this conclusion from this study should be examined in future research because it is unclear whether there is an overall advantage for learning of text content between a narrative or expository format, especially when content is controlled across genre.

However, the learning results between the text genre may be partly explained by the strong relationship between prior knowledge and expository text, as evidenced in this current study and in some prior studies (e.g., Coté et al., 1998; Kintsch, 1994, 1998; McDaniel & Einstein, 1989; McNamara, 2004; Wolf, 2005, 2007, 2010; Zwaan, 1994). For example, this present study showed the strong pre-to-post KS similarity in the expository text than the narrative text by both proficiency participants, supporting some previous findings that expository texts triggers readers to make more efforts to integrate prior knowledge with text content (i.e., more attention to the integration of content with prior knowledge) while narrative texts triggers readers to make more efforts to comprehend the events being described in the narrative (i.e., more attention to individual text concepts/elements). In this regard, if the prior knowledge has misconception or poorly structured relations of conceptions, then this idiosyncratic prior knowledge would have more negative effects for the comprehension of the expository text than that of the narrative text because of their relatively strong tendency to incorporate the content with prior knowledge. According to the graph centrality measures in this study, all the participants’ pre-reading KSs had perhaps inappropriately complicated or otherwise
deficient structures (compared to the lesson texts) regardless of their proficiency levels (see Figure 16). Thus, it would be reasonable to assume that these idiosyncratic pre-reading KSs may more interfere with comprehension on the expository text content because expository reading apparently places a strong emphasis on integration of text content with prior knowledge, which might negatively influence their comprehension posttest scores, although memory for the expository content was better than that for the narrative; whereas the narrative readers were less interfered by their prior KS because of their strong emphasis on the individual text elements described in the text (or they might take advantage of the narrative cues that facilitate comprehension), which might positively influence their posttest scores, although memory for the narrative content was relatively less than the expository.

To sum up, for the high proficiency participants, there was no difference for either memory or learning as a function of task language. However, there was a distinct interaction with text genre for the reading performances. Memory for the text content (measured as text-to-essay similarity) were greater in the expository text (than the narrative text), but no difference between genres for learning (measured as comprehension posttest). These finding could indicate that memory and learning of the same text content may differ depending on the text genre, but not on task language, at least for this high proficiency Korean English language learners.

### 5.4 Research Question 3: The validity of this KS measure

This investigation sought to contribute to text genre research in L2 reading context using the KS analysis methods validated in various kinds of L1 and L2 reading studies; for example, in monolingual settings with English (Clariana et al., 2014), Dutch (Fesel et al., 2015), and Chinese (Su & Hung, 2010) and also in bilingual settings with Dutch-English (Mun, 2015), Korean-English (Kim & Clariana, 2015, 2016, 2017), and Chinese-English (Tang & Clariana, 2016). Using the KS approach, this current research reported the expected findings that are consistent with those of prior research, supporting the validity of the KS measures. This study also reported the unexpected findings that contradict those of prior studies, but these findings are consistent with the pilot studies using the
same set of lesson text materials, *The Circulatory System*, with the same Korean English language participants, thus supporting the validity of the KS measure (see Table 11 for result summary).

Previous studies in both L1 and L2 reading fields have not conceptualized KS as this investigation does. This investigation, thus, presents a novel approach to measure readers’ mental representation of reading comprehension, as KS. In this investigation, its appropriateness and validity were clearly demonstrated as a useful measure of KS contained in the English language learners’ productions (sorting task and summary essay) that allow researchers (and teachers) to visually describe and distinguish the mental representation of narrative and expository text. If further confirmed, L2 reading studies applying this KS approach can open up a new avenue whereby L2 reading processing can be scrutinized in a more in-depth manner, thus informing and enriching the KS approach to reading research in an L2 as well as L1.

**5.5 Implications**

**5.5.1 Low proficiency readers**

The low proficiency participants’ post-reading KSs (i.e., as essays) were more like their pre-reading KSs (as sorting tasks) in the L2 task and in the expository text (i.e., stronger pre-to-post similarity; refer back to Tables 5 and 6), and so these post-reading KSs had no significant relationship with the posttest comprehension performance (refer back to Table 9). However, their post-reading KSs were more like the L2 lesson text in the L1 task and in the narrative lesson text (i.e., stronger text-to-essay similarity; refer back to Tables 7 and 8), and so these post-reading KSs had significant relationship with their posttest performance (refer back to Table 9). These findings suggest that their memory and learning of L2 text content may be greater in the *LI* task (than the L2 task) and in the *narrative* text (than the expository text).

These findings from the low proficiency participants can have practical implications for their L2 reading instruction. In terms of task language, this current investigation demonstrated the positive
role of L1 use for L2 reading replicating prior studies, thus, low proficiency readers’ L2 reading comprehension can be improved if educators consider appropriate L1 use by activating and exploiting their L1-based background knowledge in response to the L2 use task. For example, a teacher can ask L1-related experiences/memory before and/or after L2 text reading or provides L1 supporting reading materials for to-be-learned L2 text content for their low proficiency L2 students. Several monolingual reading studies have demonstrated that activating and incorporating relevant background knowledge for L1 text comprehension greatly influences how readers comprehend, remember, and learn the L1 text content (e.g., Jonassen & Grabowski 1993). This present investigation provides clear evidence of why processing an L2 text by activating and exploiting L1-based knowledge leads to superior reading outcomes compared with not engaging in this process, especially for the low proficient L2 readers who do not have enough L2 related-knowledge structure to process the L2 text successfully.

In terms of text genre, this current investigation confirmed the superior reading comprehension outcomes in the narrative lesson text replicating prior studies, thus, low proficiency readers’ L2 reading comprehension can be improved if educators consider providing support for including narrative texts or narrative reading activities in L2 reading curricula for the low proficiency L2 readers. But it would be not necessarily to teach to-be-learned content in a narrative genre because as shown by this study and prior studies, if narrative texts triggers readers to place relatively greater emphasis on the events described in the narrative, then the to-be-learned content could be delivered more successfully if it is essential to the story, rather than inessential. For example, it would be beneficial enough for a teacher to consider the extent to which the to-be-learned content is tied to the narrative events, rather than considering the narrative genre as a means of teaching the text content. Some of school topics that have inherently narrative structure, such as history, could be likely incorporated with the narrative.

However, other topics that have inherently expository structure, such as anatomy, may not be able to be successfully incorporated into a narrative. In these expository-type content cases, the reading comprehension can be improved if educators consider the benefit of prior knowledge for the expository text. This study demonstrated a prior knowledge advantage in the expository text
replicating pilot studies, expository texts triggers readers to place relatively greater emphasis on integrating to-be-learned content with prior knowledge of readers. This finding could suggest the importance of identifying preexisting conception and/or misconceptions of the to-be-learned content when it is delivered in an expository format. As shown by this present investigation, idiosyncratic pre-reading KSs of the low proficiency participants were largely transferred to their post-reading KSs when reading the expository lesson text that in turn negatively influences their memory and learning, even for the high proficiency participants. Thus, educators should consider when using expository texts that prior knowledge would be more important predictor of comprehension of expository texts than narrative texts for their low proficiency L2 readers.

5.5.2 High proficiency readers

The high proficiency participants had no interaction with task language for either memory or learning and also for prior knowledge interaction, but they had a distinct interaction with text genre for the reading performances. First, although expository readers showed better memory performance than the narrative readers (refer back to Table 7 and 8), there was no difference between text genres for learning, neither narrative nor expository genre appears to be superior in delivering content to the high proficiency L2 readers for their L2 text learning (refer back to Table 9), consistent with earlier findings from L1 literature reporting no difference between these genres. When the interaction with prior knowledge was taken into consideration, however, clear differences emerged between narrative and expository genres (refer back to Table 5 and 6). The high proficiency expository readers utilized their prior knowledge more during essay writing than did the narrative readers, as with the low proficiency participants. These results support the processing differences proposed from our pilot studies and other prior studies, reporting that expository readers are primarily concerned with integrating to-be-learned content with their prior knowledge while narrative readers are more concerned with building mental representation of individual text elements described in the narrative, less concerned with prior knowledge integration.
These findings from the high proficiency participants can have practical implications for their L2 reading instruction. The results can suggest that high proficiency readers with lower domain knowledge would learn best from the narrative text while the high proficiency readers with higher domain knowledge would learn best from the expository text. For example, expository texts may not be beneficial for the high proficiency L2 readers (and also the low proficiency L2 readers) who do not have enough prior knowledge and/or have misconception of to-be-learned content because of expository readers’ tendency to incorporate content with prior knowledge. In this situation, narrative format could be more beneficial for the lower knowledge readers because a story can provide at least some types of mental structure of the to-be-learned content and/or provide the narrative cues that facilitate comprehension. However, it would be important to note that learning text content in a narrative format may result in a substantially linear KS that related to the central story, as evidenced by graph centrality values in this study, because of the nature of narratives or probably the lack of the readers’ processing effort (e.g., prior knowledge integration). Thus, theoretically, the learning gains from narrative texts may decay from memory more quickly than the gains that is integrated with prior knowledge from expository texts, so follow-up instruction after the learning in a narrative format would be necessary to hold up the gains for the lower knowledge readers – this can be another important issue for future research to examine the extent to which the learning gains hold up over time between text genres. To sum up, high proficiency readers’ L2 reading comprehension can be improved if educators pay attention to the different processing focus between genres when teaching and/or designing the narrative and expository reading materials.

5.6 Limitations

This current study is subject to several limitations. First, L1 general reading ability cannot be ruled out in this L2 reading study, given that L2 reading success is dependent both on L1 reading ability and L2 proficiency, although it was found that L2 proficiency is a much greater predictor of L2 reading comprehension (e.g., Carrell, 1991; Foss, 2009). This experiment did not measure
participants’ general L1 reading ability so participants’ L2 reading performances shown in this study may be aided by their L1 reading ability or strategies.

As in any experimental study, there are also limitations in generalizability to other settings, thus, these findings should not be over-generalized. Further, the sorting map as a pre-reading task completed by all participants preceded the post-reading tasks (in this case, essays and posttest) and so sorting may have influenced reading and the post-reading performance. Possibly, the findings from the current study may or may not be observed if the sorting task is not used (Tang & Clariana, 2017).

It is also important to note that the narrative in the current study (originally from Wolfe et al., 2007) may be seen as an artificial device for delivering circulatory system content because some of the narrative may be not necessary in order to explain the content. For example, including the names of the heart chambers may create the possibility that the narrative readers could follow the story while paying more attention to the factual content that is not essential to the central story. Perhaps, this artificial narrative characteristic may have led to the results which appears to contradict with the prior studies using more authentic narratives, for instance, less relationship with prior knowledge in the current narrative.

5.5 Future research

The present study opens several possible avenues for future inquiry. Concerning prior knowledge integration, this study showed relatively strong retrieval of prior knowledge from memory in the expository text than the narrative text for both proficiency participants (expository readers with a greater pre-to-post similarity), which appears to contradict earlier findings showing a prior knowledge advantage for the narrative text. Although this discrepancy could be explainable by the artificial characteristic of the current narrative in this study as discussed above, this conclusion should be examined in future research with a more careful narrative text design. If follow-up studies have produced consistent findings with a greater integration with prior knowledge in expository texts, it could be suggested that possession of more prior knowledge may be necessary for memory and
learning from the expository texts than the narrative. Then the optimal amount of prior knowledge expository readers should possess about the topic needs to be addressed in future research.

In terms of memory, the results suggest that narrative texts would be more beneficial to the low proficiency readers as expected (narrative readers with a greater text-to-essay similarity), but unexpectedly this result did not hold for the high proficiency readers (expository readers with a greater text-to-essay similarity) perhaps due to the stronger competition between the ‘expository like’ circulatory system pre-reading KS and post-reading KS engendered from the narrative text in the high proficiency participants. Thus, this conclusion should be examined in future research with a different domain text topic.

In terms of learning, the results suggest that narrative texts would be more beneficial to the low proficiency L2 readers as expected (narrative readers’ high posttest score), but it is unclear whether there is an overall advantage for learning of text content between text genres for the high proficiency readers (no difference in posttest score). Although this finding from the high proficiency is consistent with monolingual research in which content is controlled across text genres, this conclusion should be examined in future research with both sets of controlled and uncontrolled narrative and expository texts.

The findings from the present study seem to support the different processing focus between text genres proposed from earlier studies, more emphasis on understanding the events in the narrative vs. more emphasis on integration of text content with prior knowledge in the expository, if further confirmed, then it would be also interesting to compare the extent to which learning gains from the different processing focus last over time between text genres.

5.5 Conclusion

This study applied KS analysis methods to investigate the interactions between pre-reading KS and text genre (Question 1) and between text genre and post-reading KS (Question 2) by the low and high proficiency levels. By providing additional insights into the relationships, it is hoped that KS
analysis methods used in this study, not yet fully addressed in L2 reading studies, contribute to the measure of mental representation of L2 readers and thus to the understanding of the L2 reading process. It is further hoped that the findings related to text genre will encourage the inclusion of narrative texts or narrative reading activities in addition to expository texts in the L2 reading curriculum, at least for the low proficiency L2 readers.
Reference


Ifenthaler, D., Masuki, I., & Seel, N. M. (2011). The mystery of cognitive structure and how we can detect it: tracking the development of cognitive structures over time. Instructional Science, 39(1), 41-61.


Kim, K., & Clariana, R. B. (accepted, 2017). Applications of Pathfinder Network scaling for identifying the optimal use of a first language to support second language text comprehension. Educational Technology Research and Development


for subgroups of comprehenders. *Learning and Individual Differences*, 22(1), 100-111.


APPENDIX A

Consent Form

Title of Project: Visualizing reading comprehension: Understanding the influence of text structures on readers’ knowledge structures

Principal Investigator: Kyung Kim
314 Keller Building, University Park, PA 16802
(814) 441-1849; kxk997@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore the influence of text genre (narrative vs. expository) on second language reader’s knowledge structure.

2. Procedures to be followed: You will be asked to sort terms in English and Korean and read either English narrative or expository text passage.

3. Discomforts and Risks: There are no risks in participating in this research beyond those experienced in everyday life.

4. Benefits: This research might provide a better understanding of the relationship between the text genre and reading comprehension in Korean and English languages. This information could help us develop more effective methods for helping second language reader’s text comprehension.

5. Duration: It will take about 30 minutes to read the story and complete the sorting tasks and summary writings.

6. Statement of Confidentiality: Your participation in this research is confidential. The study does not ask for any information that would identify who the responses belong to. The Pennsylvania State University’s Office for Research Protections, the Institutional Review Board and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this research study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared because your name is in no way linked to your responses.

7. Right to Ask Questions: Please contact Kyung Kim (kxk997@psu.edu) with questions, complaints or concerns about this research. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by Kyung Kim.

8. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to complete and task that you do not want to do.
You must be 18 years of age or older to take part in this research study.

Completion and return of the survey implies that you have read the information in this form and consent to take part in the research.

Please keep this form for your records or future reference.

By signing this consent form, you indicate that you are involved in this research and agree to allow your information to be used and shared as described above.

___________________________  ________________  ________________
Signature of Participant  Date  Printed Name
APPENDIX B

Sorting Task

<Pre-Reading Sorting Task> Review the 17 keywords in the list below and then click and drag these 17 keywords into the box; move related concepts closer together and unrelated ones further *apart until it feels right* to you. THERE IS NO CORRECT ANSWER!

arteries, body, capillaries, carbon dioxide, cells, chambers, circulatory system, left atrium, left ventricle, lungs, oxygen, pulmonary loop, pulmonary veins, right atrium, right ventricle, systemic loop, veins
**APPENDIX C**

*Heart Circulatory System*

**Expository version**

Virtually all kinds of animals have a circulatory system. One function of the circulatory system is to deliver oxygen to the cells of the body. Another function is to remove carbon dioxide from the cells. The three main components of the circulatory system are the heart, blood vessels and blood. Blood flows through the circulatory system in two separate but connected loops to accomplish these functions.

The systemic loop is a network of arteries and veins going out to the body and back to the heart. Blood travelling to the body is pumped out of the left ventricle, one of the bottom chambers of the heart. From the left ventricle, blood travels out of the aorta and through the arteries. Arteries, a type of blood vessel, carry blood away from the heart. In between arteries and veins are the smallest blood vessels, called capillaries. The capillaries are where oxygen and carbon dioxide are exchanged between the red blood cells in the blood and the cells of the body. The oxygen and carbon dioxide pass through the thin walls of the capillaries. Veins, the third type of blood vessel, carry blood back to the heart. From the veins of the body, blood enters one of the upper heart chambers, the right atrium. It passes through a valve to the right ventricle. The heart is divided into left and right sides by a muscular wall called the septum. From the right ventricle, the other bottom heart chamber, the blood goes out to the lungs. The path of blood to the lungs and back represents a separate loop in the circulatory system called the pulmonary loop. In the lungs, the red blood cells discard carbon dioxide. At the same time, oxygen enters the lungs and is absorbed by the red blood cells. This oxygen-rich blood then travels back to the heart through the pulmonary veins. Blood from the lungs enters the left atrium, the other upper chamber of the heart. From there, it passes to the left ventricle and the continuous loops begin again.

The heart, blood vessels and blood must all function together. The circulatory system also carries out other essential functions. All mammals have a circulatory system.
Narrative version

Alex worked for many years on a machine that would allow him to become tiny. One day, he finally finished the machine and made himself tiny. He was so light that he could fly. When passing by a woman, Alex got sucked into her lungs. He held on to an oxygen molecule that had also entered the lungs. The molecule was absorbed into a red blood cell in the blood. He wanted to find a way back outside. Alex was on an adventure through the blood. He saw that carbon dioxide molecules were released from the blood back into the lungs. He needed to hold on to a carbon dioxide molecule and get back to the lungs. First, Alex travelled through the pulmonary veins, which are a type of blood vessel that return blood to the heart from the lungs. He entered the heart into one of the top chambers, the left atrium. Next he went to the left ventricle, which is one of the bottom heart chambers. This chamber pumped Alex out along the systemic loop, a network of arteries and veins going to the body and back to the heart. First he travelled through the arteries, which are blood vessels that carry blood away from the heart. After a while, the oxygen molecule reached the small blood vessels called capillaries. In the capillaries, oxygen was absorbed into the cells. Carbon dioxide was passing through the capillary walls back into the blood. Alex quickly released himself from the oxygen molecule and grabbed on to a carbon dioxide molecule. The carbon dioxide molecule went back toward the heart through the veins. The veins emptied into the right atrium, the chamber of the heart that receives blood from the body. From the right atrium, Alex was pushed down through a valve into the right ventricle, the other bottom heart chamber. He could see the septum, a muscular wall that divides the heart into right and left sides. The right ventricle pushed Alex out the pulmonary loop, which is a separate loop of the circulatory system that goes to the lungs and back. Soon, he was passing through the thin wall of a capillary in the lungs. He was breathed out into the air. The adventure was over.
APPENDIX D

A math task

Cathleen은 3/4 마일에 개를 데리고 갈 계획이었습니다. 비가 내리기 시작한 후, 그녀는 그 거리의 1/2 걸음을 걷기로 결심했습니다. Cathleen이 그녀의 개를 몇 마일이나 갔을까요?

F \( \frac{1}{4} \)

G \( \frac{3}{8} \)

H \( \frac{4}{6} \)

J \( \frac{4}{8} \)

어느 방정식이 곱셈의 제로 성질을 나타내는가?

A \( 9 \times 0 = 0 \)

B \( 9 \times 0 = 9 \)

C \( 9 \times 0 = 1 \)

D \( 9 \times 1 = 0 \)

Phillip은 식 \( 2^7 \)을 써дает. 어떤것이반복 곱셈을 사용하여 같은 식을 쓰는 또 다른 방법입니까?

F \( 2 \times 7 \)

G \( 7 \times 7 \)

H \( 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \)

J \( 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \)
네드는 다섯 번째 점을 그린 다음 모든 점을 연결하여 아래의 표에 5 각형을 그려야합니 다.

어느 좌표가 오각형을 완성하지 못했을까요?

F (5, 8)  
G (6, 7)  
H (7, 2)  
J (8, 4)
APPENDIX E

Essay task

<Post-Reading Summary Writing > Write down as much as you can remember from the passage you just read. If you could not remember the exact wording of the passage, they should be as close as possible.
## APPENDIX F

*Circulatory system knowledge test*

<table>
<thead>
<tr>
<th>Questions</th>
<th>Correct answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which chamber of the heart does the blood returning from the body enter first?</td>
<td>Right atrium</td>
</tr>
<tr>
<td>What is the protein which makes quick oxygen/carbon dioxide transfer possible?</td>
<td>Hemoglobin</td>
</tr>
<tr>
<td>How many molecules of oxygen can each such protein carry?</td>
<td>Each protein can carry four molecules of oxygen</td>
</tr>
<tr>
<td>How many continuous, closed circuits of blood are there from the heart? Name them.</td>
<td>Two: pulmonary and systemic</td>
</tr>
<tr>
<td>Where does the blood entering the left atrium come from?</td>
<td>Pulmonary vein (or lungs)</td>
</tr>
<tr>
<td>Where does blood entering the left ventricle come from? The right ventricle?</td>
<td>Blood entering the left ventricle comes from left atrium. Blood from right ventricle comes from right atrium</td>
</tr>
<tr>
<td>The pacemaker is the common term for what specific part of the heart? Where is it located?</td>
<td>Sinoatrial (or SA) node located in the wall of the right atrium</td>
</tr>
<tr>
<td>Which side of the heart is larger? Why?</td>
<td>Left side. It has to pump blood to the entire body</td>
</tr>
<tr>
<td>What is unusual about the pulmonary veins?</td>
<td>They carry oxygenated blood</td>
</tr>
<tr>
<td>What are the names of the main veins which carry blood back to the heart from the body? How many such veins are there? From what part of the body does each such vein return blood?</td>
<td>Superior and inferior vena cavae. Two. Superior comes from the upper part of the body and inferior from the lower</td>
</tr>
</tbody>
</table>
## APPENDIX G

IRB Approval

### EXEMPTION DETERMINATION

**Date:** December 15, 2016  
**From:** Philip Frum, IRB Analyst  
**To:** Kyung Kim

<table>
<thead>
<tr>
<th>Type of Submission:</th>
<th>Initial Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title of Study:</td>
<td>VISUALIZING READING COMPREHENSION: UNDERSTANDING THE INFLUENCE OF TEXT STRUCTURES ON READERS’ KNOWLEDGE STRUCTURES</td>
</tr>
<tr>
<td>Principal Investigator:</td>
<td>Kyung Kim</td>
</tr>
<tr>
<td>Study ID:</td>
<td>STUDY00006202</td>
</tr>
<tr>
<td>Submission ID:</td>
<td>STUDY00006202</td>
</tr>
<tr>
<td>Funding:</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>
| Documents Approved: | • HRP-591 - Protocol for Human Subject Research_rev3.pdf (0.03), Category: IRB Protocol  
• supporting documents.docx (0.01), Category: Data Collection Instrument |

The Office for Research Protections determined that the proposed activity, as described in the above-referenced submission, does not require formal IRB review because the research met the criteria for exempt research according to the policies of this institution and the provisions of applicable federal regulations.

Continuing Progress Reports are **not** required for exempt research. Record of this research determined to be exempt will be maintained for five years from the date of this notification. If your research will continue beyond five years, please contact the Office for Research Protections closer to the determination end date.

Changes to exempt research only need to be submitted to the Office for Research Protections in limited circumstances described in the below-referenced Investigator Manual. If changes are being considered and there are questions about whether IRB review is needed, please contact the Office for Research Protections.

Penn State researchers are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within CATS IRB (http://irb.psu.edu).

This correspondence should be maintained with your records.
VITA

Kyung Kim

EDUCATION

2012-2017  Ph.D. Candidate
            Learning, Design, and Technology
            The Pennsylvania State University, USA

2010-2012  Master of Education
            Curriculum and Instruction
            Northwestern State University of Louisiana, USA

2000-2007  Bachelor of Arts
            Educational Foundation
            Kongju National University, Korea

EMPLOYMENT

2015-2017  Graduate Assistant, John, A. Dutton e-Education Institute,
            College of Earth and Mineral Sciences

2014-2017  Research Intern, Brain, Language, and Computation Lab,
            College of Psychology

2013-2014  Research Assistant, Learning, Design, and Technology Program,
            College of Education

2012-2013  Distinguished Graduate Fellow, Graduate School

SELECTED PUBLICATIONS


