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The effect of using a structured reading framework on middle school students' conceptual understanding within the science writing heuristic approach

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THE EFFECT OF USING A STRUCTURED READING FRAMEWORK ON MIDDLE SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING WITHIN THE SCIENCE WRITING HEURISTIC APPROACH

by

Jeong Yoon Jang

An Abstract

Of a thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Science Education
in the Graduate College of
The University of Iowa

July 2011

Thesis Supervisor: Professor Brian Hand

ABSTRACT

This study was designed to investigate the impact of using a Structured Reading Framework within the Science Writing Heuristic approach on a summary writing task, and how this framework is related to the development of students' conceptual understanding in the summary writing task. A quasi-experimental design with sixth and seventh grade students taught by two teachers in the middle school was used. Each teacher had four classes with two classes using the Structured Reading Framework (treatment) and the other two classes used the original reading framework (control). A total of 170 students participated in the study, with 83 in the control group (four classes) and 87 in the treatment group (four classes). All students used the SWH student templates to guide their written work and completed these templates during the SWH investigations of each unit. After completing the SWH investigations, both groups of students were asked to complete the summary writing task at the end of each unit. This process was replicated for each of the two units. All student writing samples collected were scored using an analytical framework and scoring matrices developed for the study. A total of 588 writing samples were included in the statistical analysis. Results indicated that the treatment group who used the Structured Reading Framework performed significantly better on the Summary Writing task than the control group. The results suggest that the using of the Structured Reading Framework in prompting and guiding the reading activities within the SWH approach have an impact on the development of conceptual understanding. In addition, it appears that the Structured Reading Framework impacted the development of conceptual understanding in the Summary Writing task by providing a scaffold to assist students' knowledge construction.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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has been approved by the Examining Committee
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ABSTRACT

This study was designed to investigate the impact of using a Structured Reading Framework within the Science Writing Heuristic approach on a summary writing task, and how this framework is related to the development of students' conceptual understanding in the summary writing task. A quasi-experimental design with sixth and seventh grade students taught by two teachers in the middle school was used. Each teacher had four classes with two classes using the Structured Reading Framework (treatment) and the other two classes used the original reading framework (control). A total of 170 students participated in the study, with 83 in the control group (four classes) and 87 in the treatment group (four classes). All students used the SWH student templates to guide their written work and completed these templates during the SWH investigations of each unit. After completing the SWH investigations, both groups of students were asked to complete the summary writing task at the end of each unit. This process was replicated for each of the two units. All student writing samples collected were scored using an analytical framework and scoring matrices developed for the study. A total of 588 writing samples were included in the statistical analysis. Results indicated that the treatment group who used the Structured Reading Framework performed significantly better on the Summary Writing task than the control group. The results suggest that the using of the Structured Reading Framework in prompting and guiding the reading activities within the SWH approach have an impact on the development of conceptual understanding. In addition, it appears that the Structured Reading Framework impacted the development of conceptual understanding in the Summary Writing task by providing a scaffold to assist students' knowledge construction.

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CHAPTER I

INTRODUCTION

Science Literacy and Language

Science literacy is viewed as an essential goal of science education (DeBoer, 2005; Anthony et al., 2010). Over the past decade, several definitions of scientific literacy have been suggested. Norris and Phillips (2003) suggested two essential senses of science literacy ─ the derived sense associated with the understanding of science concepts, and the fundamental sense related to how to use language to discuss and explore science. Arguing that the concepts of scientific literacy pay attention to the derived sense of literacy but tend to disregard the fundamental sense, researchers have stressed that an interaction between these two senses is required for someone to become scientifically literate (Norris & Phillips, 2003; Yore et al., 2007; Hand, 2008). By realizing that both the derived sense and the fundamental sense of literacy are critical to the development of scientific literacy, Hand (2008) expanded the definition of Norris and Phillips to include different modes of representation to the derived sense of science literacy. He argued that while this is implicit within reading and writing, there is a need to understand that different modes of science are critical to the concept of reading and writing.

Many science educators have emphasized the importance of language in doing and learning science and in science literacy (Yore, Florence, Pearson, & Weaver, 2006; Yore, Bisanz, & Hand, 2003; Norris & Phillips, 2003; National Research Council, 1996). In considering the importance of language to science learning and inquiry, the use of language in context becomes central to the process of learning and is key in developing science knowledge and thought (Vygotsky, 1962; Norris & Phillips, 2003). As Wallace (2004) asserted, students' understandings of science cannot occur without the active use of language, such as reading and writing. In other words, by engaging in discussing and negotiating their investigations in both oral and written forms, students learn science (Driver, Newton, & Osborne, 2000; Duschl, 1990; Kuhn, 1993).

There are two perspectives among researchers about how to introduce language instruction within the science classroom. Many researchers suggest that there is a need to learn to use the language prior to successfully learning science, which views language from a mechanistic view (Hand, 2008). In this perspective, students must engage with the structure of the genres of science as a precursor to doing science (Halliday & Martin, 1993). However, there is inconclusive evidence for this learning-to-use language position (Klein, 1999). The opposing position views language as a learning tool (Hand, 2008) where language practice is embedded within the learning experience (Gee, 2004). In this position, language practices become embedded within science and not a separate entity. Prain (2006) asserted that using the language as a learning tool approach provides much more potential for learning gains than learning about language separate from the context of its use. Studies in relation to the language-to-learn position have shown positive results in terms of helping students learn science (Rivard & Staw, 2000; Hand, Hohenshell, & Prain, 2004; Gunel, Hand, & Prain, 2007; McDermott & Hand, 2010). On the other hand, several researchers suggest the need for explicit instruction on how to talk, read, write, represent, view, and interpret science (Yore & Treagust, 2006; Halliday & Martin, 1993; Hand and Prain, 2006). Learning how to talk, write, and read science frequently requires embedding explicit language tasks and instruction into science inquiry to enhance the fundamental sense of science literacy, which, in turn can enhance the derived sense of science literacy ─ talking, writing, and reading to learn science (Yore, 2000).

Research studies have shown that integration of language arts such as reading, writing, and talking into science instruction has a positive effect on student achievement (Guthrie, 1996; Romance & Vitale, 2001). However, past research focused singularly on reading, writing, or talking in science learning (Hand & Prain, 2006) rather than on a more integrated approach to language use. There is a need to incorporate language instruction into the science classroom to develop students' scientific literary (Gee, 2004; Rivard & Straw, 2000). Researchers have argued that oral language is necessary, but not sufficient, to do and learn science (Norris & Phillips, 2003; Yore, 2004). They suggest however that there is a need to develop the facility to read and write scientific texts in the fundamental sense to learn science (Norris & Phillips, 2003). As Wallace, Hand, and Prain (2004) argued, students' understanding of science cannot take place without the activities of reading and writing in the construction and reconstruction of scientific ideas. When "writing is to be used as a learning tool, it would be more useful to deploy it in combination and as integrated with other forms of learning and discourse, such as reading, classroom discourse and group discussions" (Tynjala, Mason, & Lonka, 2001, p. 14).

Writing-to-Learn in Science Learning

The focus on using writing as a learning tool has increased since the 1970's with a number of models put forward to explore the cognitive process of how writing supports learning. A common feature among the cognitive models associated with writing-to-learn approach is the importance placed on an interaction between the writer's content knowledge and rhetorical knowledge (Hand, 2007) and some kind of cycling between these two knowledge bases. Moreover, these models have stressed that writing can lead to better learning (Cavagnetto, 2006), and recognizing the need to develop specific writing tasks that encourage learning (Klein, 2006).

Current efforts in science education stress the need for writing-to-learn strategies to be used in science classrooms (Yore et al., 2003). Writing-to-learn strategies are critical in the process of helping students understand science as a discipline and constructing rich understandings of the science concepts being studied. Several studies show that incorporating writing-to-learn activities in science classrooms promotes science conceptual understanding. A meta-analysis on writing-to-learn strategies by

Bangert-Drowns, Hurley, and Wilkinson (2004) showed positive benefits to be gained through using these strategies. Hand, Hohenshell, and Prain (2004) suggested that the more writing opportunities students have the more potential they have to increase their conceptual understanding. Further to this, Gunel, Hand & McDermott (2009) also found that embedded writing-to-learn activities help secondary school students gain conceptual understanding of scientific topics.

Different kinds of writing activities lead students to think about information in different ways and have different effects on learning (Langer & Applebee, 1987). For example, Hildebrand (1999, 2004) showed that diversified writing tasks, including more imaginative writing, assisted students' learning processes, had strong motivating effects, and improved learning outcomes. Gunel, Akkus, Hohenshell, and Hand (2004) demonstrated that students' performance in answering higher-order cognitive questions was enhanced when they used a modified writing genre compared to students who wrote a traditional laboratory report.

Another critical outcome of the writing research is that there is broad agreement about the importance of audience awareness. Effective writers develop an understanding that the language and content they use and create are interactive and that these must be taken into account by analyzing who their audience is (Engler, Raphael, Anderson, Anthony, & Stevens, 1991). In examining the impacts of different audiences on students' writing-to-learn activities, Gunel, Hand and McDermott (2009) found that students who wrote for their peers or for younger students performed significantly better on biology conceptual questions than students who wrote for their teacher or parents.

Several studies have attempted to provide evidence that explicit instruction for writing in science is necessary for students to accumulate the full benefit of writing for learning. Keys (1999) found that the majority of middle school students tended to write more lists of observation and description type clauses than inferential or explanatory clauses about authentic investigations when given no explicit writing instruction. Guided activities including questioning, a ‘trash and treasure’ activity for deciding on the relevancy of information, note-making, sorting, and peer review helped students gain a greater depth of understanding of science inquiry. According to the genre-related hypothesis (Klein, 1999), writers elaborate their knowledge while wrestling with the demands of specific writing tasks. The use of teacher scaffolding and structured frames allow students to develop discourse knowledge about the specific genre (Yore, Bisanz, Hand, 2010). Keys (1994) has suggested that providing full writing strategy support, during which important characteristics of the writing are made explicit, might enhance students’ performance. Explicit writing tasks and instruction embossed in the authentic context of scientific inquiry should be provided as an integral part of science courses (Hand, Prain, Lawrence, & Yore, 2000). Current research suggests that sstudents need to be provided with structured support and explicit instruction on how to transform their conceptual network into arguments and explanations. One example is the Science Writing Heuristic (SWH) approach, which is an argument-based inquiry approach for scaffolding the generation of knowledge from science investigations, and students’ explicit writing (Hand, Prain, & Wallace, 2002). The SWH approach integrates the disciplines of writing and reading during science investigations to create an authentic scientific inquiry environment in which dialogical interactions replace traditional didactic approaches (Hand, 2008).

The Science Writing Heuristic (SWH) Approach

The research proposed here was conducted within the Science Writing Heuristic (SWH) approach classroom context. Hand and Keys (1999) developed the SWH approach, which is an argument-based inquiry approach that incorporates the importance of both language use in learning and science argument into scientific inquiry (Keys, Hand, Prain, & Collins, 1999). In the SWH approach, students complete two distinct writing activities: i) the SWH templates during scientific inquiry activities, and ii) summary writing tasks at the end of the unit. Several empirical studies have shown that the SWH approach influences student conceptual understanding and cognitive engagement in science (Hand, Wallace, & Yang, 2004; Hohenshell & Hand, 2006; Greenbowe & Hand, 2005). Hand, Wallace, and Yang (2004) found that seventh grade students who used the SWH approach performed significantly better than control students on science conceptual questions. Moreover, Greenbowe and Hand (2005) suggested that student understanding of chemistry concepts improved as a result of using the SWH approach.

The SWH approach provides students with a template to guide science activity and reasoning in writing (Hand, 2008), which is designed to help them construct scientific knowledge within a scientific inquiry (Keys, Hand, Prain, & Collins, 1999). The student template of the SWH approach is a semi-structured writing form that scaffolds students' reasoning and facilitates meta-cognition about their investigations (Hohenshell & Hand, 2006). By using the template, students are encouraged to generate questions, beginning ideas about a topic, design procedures, collect and interpret data, identify claims and evidence, challenge ideas of others through discussion, compare their ideas to alternative sources, analyze contributions of others, and reflect on changes to their ideas. Furthermore, the student template of the SWH guides students to make a connection between the generated questions, procedures, data, claims and evidence (Keys, Hand, Prain, & Collins, 1999).

The studies associated with the SWH approach have indicated that the SWH student template is useful in scaffolding students' conceptual understanding, writing, and critical thinking (Keys, 2000; Rudd, Greenbowe & Hand, 2001; Hohenshell & Hand, 2006). For example, Keys (2000) examined students' thinking processes while they wrote laboratory reports using the SWH template. She found that nine of the sixteen students demonstrated scientific problem solving strategies, including producing hypotheses and evidence, examining patterns in the data, and making general knowledge claims. She asserted that the act of writing using the SWH template can directly stimulate science learning. In another study, Hohenshell and Hand (2006) found that ninth and tenth grade students engaged in the SWH approach performed significantly better on conceptual questions after a summary writing activity compared to students in a control group. They indicated that the SWH template provides opportunities for students to think critically and reason about the meaning of their laboratory data while also promoting the development of scientific concepts.

Purpose of the Study

Recently, the benefits of using the SWH approach have been examined in different cultural settings to determine whether the same benefits are realized. A study from Korea showed the SWH approach showed significant improvement of students' conceptual understanding and cognitive engagement in science (Nam, Choi, & Hand, 2010), which is parallel to results of studies in the US. In the study from Korea, students used the SWH student template the included a modified embedded reading framework. This modified reading framework (termed Structured Reading Framework), as a part of SWH student template, is a scaffolded written framework guiding note-taking during the reading activity. The summary writing task is the final activity incorporated at the end of the unit and is viewed as a consolidation task. The summary writing is intended to help students link together the conceptual ideas dealt with in the topic. Students then completed a final summary writing activity at the end of the unit to help them consolidate the conceptual ideas dealt with in the topic. For the summary writing task, students are generally directed to write for a younger student audience.

From an analysis of the Korean students' writing samples from a pilot study, the structured reading framework activity appeared to influence the development of multi-modal use within their writing. In addition, there was a significant difference on the students' summary writing task between the group of students who used the structured reading framework within the SWH approach and those who used the original reading framework. In this respect, the question of whether parallel results would be found with students in a different cultural setting, namely the U.S. is the driving force of this study. In addition, there is a need for investigation of how the structured reading framework is related to the development of student performance. Therefore, the purpose of this study is two fold. The first is to investigate the effect of the structured reading framework activity on conceptual understanding attained as measured by summary writing task within the SWH approach. Second is to examine how the reading framework is related to the development of students' conceptual understanding in the summary writing task.

Research Questions

The research proposed here took place within the context of the Science Writing Heuristic (SWH) approach. Given the purpose of this study, the following research questions guided the design of the study:

1. Do students who use a structured reading framework embedded in the SWH template differ from students who use the original reading framework on conceptual understanding as measured by the summary writing task?
2. What is the relationship among the components of the reading framework and summary writing task?

Dissertation Overview

Chapter one provides a broad overview of this study.

Chapter two reviews literatures that forms the theoretical framework for the study, including background information on science literacy and language, reading and writing in science learning, cognitive models based on writing-to-learn tasks, and issues related to the use of multi-modal writing tasks.

Chapter three outlines the methods and procedure used in this study. The research context, description of participants, and the writing samples are described, followed by a description of the procedures. The analysis framework for evaluating the student writings and the data analysis methods are also presented.

Chapter four summarizes the results of this study, illustrating the difference between groups (treatment and control) on the summary writing task and the relationships between the components of reading framework and summary writing task, with a focus on group comparisons.

Chapter five discusses the findings and expands on the limitations and implications of the study.

CHAPTER II

LITERATURE LEVIEW

This chapter explores the theoretical framework for the present study based on a review of the literature. The section begins with a discussion about science literacy and the integration of language as a learning tool in learning science. Then discussion will continue with how reading and writing contribute to students' learning in science. The cognitive models supporting the use of writing-to-learn approach will be proposed, then a writing to learn approach, as a learning tool of in science, will be discussed. Further, the use of multi-modal writing tasks in writing-to learn will be discussed.

Science Literacy

While there are various interpretations about the construct "science literacy for all," science literacy is the intrinsic goal of science education (DeBoer, 2005; Anthony et al., 2010). Over the past decade, several definitions of scientific literacy have been suggested, including knowledge of scientific vocabulary, the understanding the nature of science, the use of scientific concepts in the real world, and the ability to read and write scientific information in the popular press (Norris & Phillips, 2003). Norris and Phillips (2003) suggested two essential senses of science literacy ─ the derived sense and the fundamental sense. They argued that the concepts of scientific literacy pay attention to the derived sense of literacy but tend to disregard the fundamental sense of literacy. The derived sense involves being knowledgeable, learned, and educated in science, which is related to the understanding of science concepts. On the other hand, the fundamental sense involves the ability to read and write about, interpret, and criticize the subject of science, which is related to how to use language to discuss and explore science. Norris and Phillips (2003) suggested that understanding the fundamental sense is critical for science learning, noting that "when scientific literacy is conceived without attention to its fundamental sense, then a critical point of access to science is overlooked" (p. 236).

Similarly, Hand (2008) pointed out that simply viewing the acquisition of science content knowledge (the derived sense) as success denies the importance of being able to apply the reasoning structures of science (the fundamental sense) required for reading and writing about science. Norris and Phillips (2003) claimed that to be scientifically literate, an interaction between these two senses is required, such that they are meant to be viewed as a complete whole, not separately. By stressing the symbiosis between these two senses, Yore *et al*. (2007) clarified the interrelationship between the fundamental and derived sense of science literacy (see Table 1). This interpretation can be applied to all students across the mandatory levels of K-12 schooling (Norris & Phillips, 2003).

Table 1. The Interacting Sense of Scientific Literacy

Fundamental sense	Derived sense
Cognitive and Metacognitive Abilities	Understanding the Big Ideas and Unifying Concepts of Science
Critical Thinking/ Plausible Reasoning	Nature of Science
Habits of Mind	Scientific Inquiry
Scientific Language Arts (reading, writing, speaking, listening, viewing and representing in science)	Technological Design
Information Communication Technologies	Relationships among Science. Technology, Society, and Environment (STSE)

Source: Yore, Pimm, & Tuan, 2007, p. 568

Language

Role and Importance of Language

Current worldwide science education reforms aimed at promoting science literacy for all students have encouraged many science educators to revisit the importance of language in doing and learning science (Yore, Florence, Pearson, & Weaver, 2006). There is general agreement that language is an integral part of science and science literacy, in particular, written language (Yore, Bisanz, & Hand, 2003). Language is a means of doing science, constructing science understandings, communicating about science, a necessary part in accessing and comprehending established scientific ideas stored in various information sources, and informing and persuading other scientists and the public about scientific ideas (Norris & Phillips, 2003; Yore, Bisanz, & Hand, 2003; Yore, Florence, Pearson, & Weaver, 2006). There is no science without the language of science (verbal, visual, mathematical, and gestural) such that science is not viewed as being separate from some form of language (Norris & Phillips, 2003). Recognition of this relationship between science and language is emphasized in the National Science Education Standards for students to become scientifically literate citizens (National Research Council, 1996). In considering the importance of language to science learning and inquiry, the use of language in context becomes central to the process of learning and is key in developing science knowledge and thought (Vygotsky, 1962; Norris & Phillips, 2003).

Efforts to promote an incorporated view of science learning with language have been made (Yore et al., 2003). Lemke (1998) stressed that any time students "do science," such as talk, read, or write about science, they are utilizing many different types of communication skills including, but not limited to, verbal, mathematical, graphical or visual, and motor expression. Language serves parallel functions for science learning by facilitating negotiations and reflections about learner-developed and metacognitivemanaged knowledge claims constructed from a collection of sensory experiences, conversations, print information sources, and prior knowledge in an interactive sociocultural context (Yore, Hand, & Goldman, 2004). Supporting the view of Norris and Phillps (2003), Wallace (2004) asserted that students' understandings of science cannot occur without the active use of language, such as reading and writing, in the construction and reconstruction of scientific ideas. In other words, students learn science while they are engaged in discussing and negotiating their investigations in both oral and written forms (Driver, Newton, & Osborne, 2000; Duschl, 1990; Kuhn, 1993).

Language as a Learning Tool for Science Learning

There has been much debate among researchers around the question of how to introduce language instruction within the classroom, particularly in relation to science classrooms. On the one hand, many researchers suggest that there is a need to learn to use the language prior to successfully learning science, which is the learning-to-use language position. This position views language from a mechanistic view (Hand, 2008). Such a position is advocated by Halliday and Martin (1993), who pointed out the need for students to engage with the structure of the genres of science as a precursor to doing science. For example, students must learn to practice writing up a laboratory report prior to using the format in laboratory activities in order to know what the laboratory structure is and how to use it. However, in a review of writing-to-learn literature, Klein (1999) found inconclusive evidence for the learning-to-use language position.

The opposing language-to-learn view suggests that students learn though using the language. In other words, students can learn about the language as a result of using the language. This position views language as a learning tool (Hand, 2008) where language practice should become embedded within the learning experience (Gee, 2004). Students need to engage with the language of the discipline as a learning tool in order to learn the content (Hand & Prain, 2006) and be provided with opportunities to engage in learning about science through using the language of science while they are doing science (Hand, 2008). In this position, language practices become embedded within science and not a separate entity. To further this argument, using the language as a learning tool provides much more potential for learning gains than learning about language separate from the context of its use (Prain, 2006). An integral part of science courses should provide explicit writing tasks and instruction embedded in the authentic context of scientific inquiry (Hand, Prain, Lawrence, & Yore, 1999). While there have not been a large number of studies that have explored the language-to-learn position in science classrooms have shown positive results in terms of helping students learn science (Rivard & Staw, 2000; Hand, Hohenshell, & Prain, 2004; Gunel, Hand, & Prain, 2007; McDermott & Hand, 2010).

As part of the ongoing debate about language instruction within the classroom, several researchers suggest the need for explicit instruction on how to talk, read, write, represent, view, and interpret science (Yore & Treagust, 2006). Science writing is different from everyday language because of its lexical density and compression of meaning and, therefore, students need explicit instruction in order to understand and master the practice of scientific writing (Halliday & Martin, 1993). From a language as a learning tool approach, Hand and Prain (2006) also asserted that students need to understand the structure of the genres used within science. Learning how to talk, write, and read science frequently requires embedding explicit language tasks and instruction into science inquiry to enhance the fundamental sense of science literacy that can be used to enhance the derived sense of science literacy—talking, writing, and reading to learn science (Yore, 2000).

Research studies have shown that integration of language arts such as reading, writing, and talking into science instruction has a positive effect on student achievement (Romance & Vitale, 2001). Historically, language arts education has been separated into four strands: reading, writing, speaking, and listening, with the recent additions of representing and viewing (Anthony et al., 2010). Past research focused singularly on reading, writing, or talking in science learning (Hand & Prain, 2006) rather than on a more integrated approach to language use. As Rivard and Straw (2000) noted, there is a need for a broader synthesis of emerging findings across modes and not just within the verbal mode. Gee (2004) emphasized incorporating language instruction, such as writing and argumentation, into the science classroom to develop students' scientific literary (Gee, 2004). He stated:

> No domain represents academic … language better than science. Science makes demands on students to use language, orally and in print, as well as other sorts of symbol systems, that epitomize the sorts of representational systems and practices that are at the heart of higher levels of school success (Gee, 2004, p. 19).

Researchers have argued that oral language is necessary, but not sufficient, to do and learn science (Norris & Phillips, 2003; Yore, 2004). Printed-based language skills are a critical element for scientists to fully become members of their scientific discourse community and effectively communicate (Yore, 2004). Furthermore, the development of modern Western science is dependent on written science texts (Norris & Phillips, 2003). Without these texts, students are severely limited in the depth and breadth of their learning of scientific knowledge, principles, and values. When "writing is to be used as a learning tool, it would be more useful to deploy it in combination and as integrated with other forms of learning and discourse, such as reading, classroom discourse and group discussions" (Tynjala, Mason, & Lonka, 2001, p. 14)

Norris and Phillips (2003) suggested that reading and writing in the fundamental sense are essential for science learning. In other words, developing the facility to read and write scientific texts is crucial to developing scientific literacy in the broad sense. By extension, Wallace, Hand, and Prain (2004) argued that students' understanding (especially as developed in middle and high school) of science cannot take place without the activities of reading and writing in the construction and reconstruction of scientific ideas.

Informing the present study is literature on language use (reading and writing) as a learning tool to promote scientific literacy in science classrooms. The present study does not focus on instruction for reading, but rather, reading as a prompt for scaffolding to help information gathering. Therefore, while the relationship between reading and learning science will be addressed, the literature related to reading in science does not include explicit instruction on reading. On the other hand, an important field informing the present study is the literature on writing task to learn as a learning tool in science learning. The section on writing in science considers the cognitive foundations that support the use of writing-to-learn activities.

Reading in Science Learning

Early science reading research was directed by a text-driven, bottom-up model that underlined decoding skills and textual attributes (Holloiday, Yore, & Alvermannn, 1994, p. 879). In this view, reading is described as taking meaning from text. However, the interpretation of reading has now moved toward the interactive reader and text models. Science reading is not simply a bottom-up process of taking meaning from printed symbols (Yore, 2003). Rather, reading is an interactive and constructive process for making meaning by negotiation understanding among the science text and the reader's concurrent experiences and memories of the topic, science, science text conventions, and science reading procedures within a sociocultural context (Yore & Shymansky, 1991). According to Valencia and Pearson (1987), the interactive–constructive view of reading

> emphasizes the active role of readers as they use print clues to 'construct' a model of the text's meaning. It de-emphasizes the notion that progress toward expert reading is the aggregation of component skills. Instead, it suggests that at all levels of sophistication, from kindergarten to research scientist, readers use available resources (e.g., text, prior knowledge, environmental clues, and potential helpers) to make sense of text. (Valencia & Pearson, 1987, p. 727)

Flood (1986) explained the role of printed language in the construction of understanding as follows:

> Readers approach texts as blueprints, as guides that enable them to construct meaning.Texts establish broad limits of possible meanings, but they do not specify a single meaning. Readers (not texts) create meaning through negotiations with authors. (Flood, 1986, p. 784)

An interactive-constructive model of reading describes readers as creating meaning to make sense of the text. This model recognizes the importance of prior knowledge, strategies, metacognitive awareness, and executive control of meaning making (Ruddell & Unrau, 1994). Reading can support constructive learning, inquiry, and problem-solving (Glynn & Muth, 1994). Through reading quality texts on a variety of science topics and applying relevant reading strategies, students broaden their domain knowledge about science, deepen their inquiry learning, and foster reading habits that can last a lifetime (Fang et al., 2008). Several research findings support the integration of reading and science. For example, Guthri *et al.* (2004) found that Concept-Oriented Reading Instruction is more effective than other instructional programmes in increasing students' reading engagement, reading comprehension, and science knowledge. Similarly, a study by Fang (2008) suggested that infusing reading into middle school science enhances science teaching and learning.

Writing in Science Learning

This section summarizes cognitive models as the foundation of writing-to-learn activities to examine the process of how writing supports learning. Next, a discussion on the relationship between science writing and learning will be addressed, focusing on how writing helps students develop a conceptual understanding of science.

Cognitive Models of Writing

The focus on using writing as a learning tool has increased since the 1970's with a number of models put forward to explore the cognitive process of how writing supports learning. Emig (1997) stated that "writing represents a unique mode of learning-not merely valuable, not merely special, but unique" (p. 122). She asserted that writing serves learning uniquely because writing as a process and product possesses a cluster of attributes that correspond uniquely to certain powerful learning strategies. Writing brings about more student awareness of relationships and connections among ideas due to its constant feedback (Emig, 1997). Emig's initial work on writing as a learning tool prompted the development of various cognitive models associated with writing (Bereiter & Scardamalia, 1987; Flower & Hayes, 1980; Galbraith, 1999; Klein, 1999; Langer & Applebee, 1987).

Cognitive models developed in the 1980's described writing as a problem solving activity. For example, Flower and Hayes (1980) proposed a goal-oriented model describing writing as a problem-solving activity. This model emphasized a goal-driven process with a hierarchical view of top-down goals. This model has three major processes: planning, translating, and reviewing, which form the central core of the act of writing. These three processes interact cognitively to create meaningful writing. Flower and Hayes viewed writing as a goal-directed activity involving the need to deal both with the process of writing and the content being addressed. In completing the task, the writer balances the goals of the task with the content knowledge to be addressed and the text being produced. This description of a goal-driven process implicates the act of writing as a learning tool (Hand, 2004).

Bereiter and Scardamalia (1987) proposed a knowledge-transforming model that is also based on writing as problem-solving. They differentiated between two models of writing: knowledge-telling and knowledge-transforming. In the knowledge-telling model, writers retrieve information already known from long-term memory and import this directly into their texts. This model is a one-way translation of experience into language (Berieiter & Scardamalia, 1987). In contrast, the knowledge-transforming process involves a dialectical interplay between two problem spaces ─ a content problem space and a rhetorical problem space ─ during a process of reflection as a way of developing knowledge. This model "involves developing an explicit representation of the rhetorical problem as hierarchy of goals and sub-goals, and requires the active transformation of content in order to satisfy goals" (Galbraith & Torrance, 1999, p. 3). As a writer engages in the content problem space and retrieves previous knowledge, this interaction impacts decisions made within the rhetorical problem space to reflect the writer's understandings and informs the content problem space for further refinement of his/her understanding.

More recently, Galbraith (1999) proposed a cognitive model emphasizing writing as a knowledge-constituting process to explain how writers learn through text production. While agreeing with some aspects of the Bereiter's and Scardamalia's model, Galbraith (1999) asserted that "the knowledge-constituting model replaces the single process problem-solving models with a dual process model" (p. 148). He argued that "problem solving can only lead to the reorganization of existing content, but cannot, by self, lead to developments in understanding" (p. 148). Galbraith's model suggests that original thinking and new knowledge can be developed through the activity of writing itself.

In the knowledge-constituting model, Galbraith identified two knowledge bases: the *writer's disposition* as the content knowledge base and the *linguistic network* as the rhetorical knowledge base. In this model, writing is a process that produces new knowledge as a consequence of an interaction between the writer's disposition and linguistic network. The writer's implicit knowledge becomes explicit because of an interaction between content knowledge and rhetorical knowledge.

When engaged in a writing task, the writer's disposition is activated, resulting in the recall of existing individual ideas stored in episodic memory. This knowledge becomes text in the form of a written utterance through the activation of the linguistic network. Galbraith suggested that each individual idea within episodic memory is not independent but connected to each other. How much activation a unit passes on to any other given unit will depend on the strength of this connection. Once a writer has written text that may consist of a few phrases, feedback occurs to produce further writing. The linguistic unit adds a new source of input to the disposition and linguistic networks. However, a linguistic unit must be produced before feedback is generated. Each time the writer cycles through this feedback, fewer connections within the disposition are activated, causing the production of different ideas because of new and different connections between the dispositional units. This cycle continues until a stable state of activation is congruent to all conflicting inputs such that no more connections are possible within the learner's cognitive network occur. Figure 1 represents Galbraith's model. In the figure, the topic and task specifications interact with the web, representing the writer's dispositional network (A). This interaction results in output messages (linguistic units)(B). This initial massage induces feedback to the writer's dispositional network (C). This process continues as further messages arise (D, E, and F) without requiring a change in the input from topic and task specification.

When the writer continues to construct text, a dispositional dialectic occurs between the writer's implicit disposition and the emerging text, which is the essential element for constituting new knowledge. Galbraith (1999) claimed that the dispositional dialectic will cause the production of more novel ideas than other forms of writing, and that these will make a relatively greater contribution to the development of the writer's understanding. However, the absolute number of new ideas produced depends on the writer's explicit understanding of the topic (Galbraith, 1999). Hand (2007) argued that the dispositional dialectic to new learning from writing can be optimized under the following conditions: the writer's strong conceptual knowledge base, a wide range of dispositions to be activated, good linguistic knowledge, and good planning and goals. To construct knowledge, students must be given opportunities to engage in the clarification of conceptual ideas through tasks that require them to cognitively deal with making connections and developing relationships in order to fulfill the task requirements (Hand, 2007).

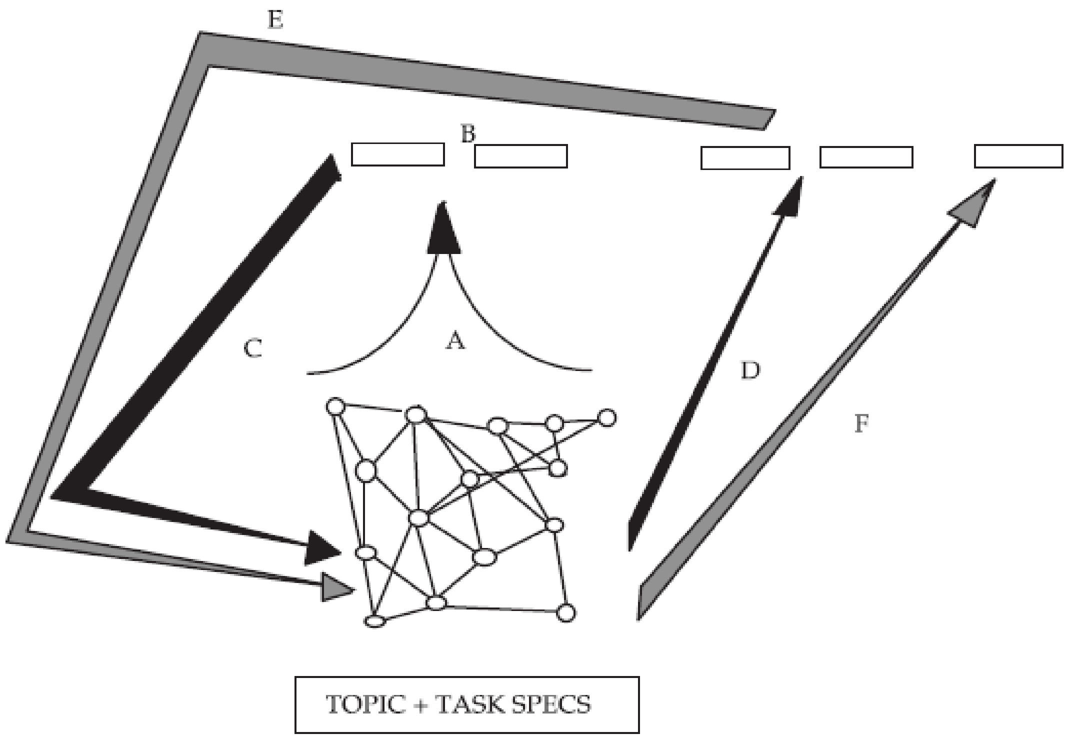

Figure 1. Diagram of Galbraith's Knowledge Constituting Model

Source: Galbraith, D. (1999). Writing as a knowledge-constituting process. In D. Galbraith, & M. Torrance (Eds.), *Knowing what to write: Conceptual processes in text production* (pp. 139-159). Amsterdam: Amsterdam University Press.

In a major review of literature regarding how writing serves learning, Klein (1999) characterized four hypotheses of how the act of writing entails cognitive processes that promote learning; the spontaneous utterance, the forward search hypothesis, the genre hypothesis, and the backward search hypothesis. In spontaneous utterance, students' writing shapes thought in the act of expression, converting tacit knowledge into more explicit knowledge. Klein described that "the *forward search* is the process through which writers recursively review the initial drafts of their texts in order to transform their ideas iteratively through operations such as deriving inferences and detecting contradictions (p. 221)." This is the view that knowledge is constructed as a result of writing text and responding to its emerging meanings. On the other hand, in *backward search,* writers learn through writing by setting rhetorical goals, generating content to satisfy these goals, and then revising rhetorical goals to address emerging content. Knowledge is constructed by setting and completing a series of rhetorical and content goals for writing. The *genre-related hypothesis* supposes that learning take place as writers address the purpose, demands, and strategies of particular genres. Focusing on the value of the linkage between form and function of genres as a framework for learning, the structure of students' texts affects their learning. From this viewpoint, the use of different genre frameworks and the knowledge of the micro- and macro- structure of texts allow students to identify the relationship between ideas and clarify their understanding of content (Hand, 2007). In order for writing to promote student learning, students must know and seek to adopt the goal of a given genre and have strategies to achieve that goal in order to transform their content knowledge into new learning (Klein, 1999).

Klein (1999) claimed that the four hypotheses ''invoke different aspects of writing, and so are mutually compatible,'' even if these ''four dimensions of writing are partially independent of one another'' (pp. 210–211). When Klein's hypothesis is applied to Galbraith's model, the initial cycling through the interactions of the writer's disposition and the linguistic network is consistent with the forward search hypothesis, while the subsequent checking for success with the writers' goals is represented in the backward search hypothesis. Greater cognitive involvement is required from students when using these multiple strategies (Klein, 2000).

More recently, Rijlaarsdam and van den Bergh (2006) proposed a ''functional dynamic approach'' to the writing process. They argued that some cognitive activities are more likely to occur earlier or later in the writing process and some activities are more likely to be helpful when occurring early or late in the process. For instance, some writers reread previously produced text as a means to trigger new thoughts and new writing, and this is more likely to occur and lead to benefits at particular points during the execution of the writing task.

There are common features among the cognitive models reviewed here associated with writing as a learning tool. Common among these cognitive models of writing as a learning tool are the importance of an interaction between the writer's content knowledge and rhetorical knowledge (Hand, 2007) and some kind of cycling in writing activities. Moreover, in their assertion that writing can lead to better learning (Cavagnetto, 2006), these models recognize the need to develop specific writing tasks that encourage learning (Klein, 2006).

Writing-to-Learn Approaches in Science

Writing-to-learn strategies are viewed as being critical in the process of helping students understand science as a discipline and constructing rich understandings of the science concepts being studied. Writing is an effective tool to promote scientific literacy in classrooms (Yore & Treagust, 2006) because it has potentially communicative and generative aspects in regard to science knowledge. Written composition provides a record of thought that can be read by an outside audience, as well as by the author.

Researchers have investigated whether incorporating writing-to-lean activities in science classrooms increase science conceptual understanding. Empirically, while results are not universal, several studies show that writing promotes science conceptual understanding. A meta-analysis on writing-to-learn strategies by Bangert-Drowns, Hurley, and Wilkinson (2004) recognized that there are positive benefits to be gained through using these strategies. For instance, Fellows (1994) examined the learning of sixth grade students involved in a conceptual change unit on matter and found that their written explanations gradually became closer to the targeted scientific explanations. Fellows (1994) maintained that more opportunities for writing explanations led to better logical arguments and conceptual change. Mason and Boscolo (2000) reported that fourth grade students involved in writing activities using writing-to-learn strategies were able to achieve deeper conceptual understanding and metacognitive awareness of the changes in their own knowledge structures compared to students in a non-writing group. Hand and colleagues (Hand et al., 1999; Hand, Wallace, & Yang, 2004; Prain & Hand, 1996) suggested that transforming scientific language for an audience other than the teacher promotes both greater conceptual understanding of the content and a greater understanding of different discourse styles when communicating in science. As shown by Wallace (2004), when writing for a different audience, scientific language needs to be unpacked and explained using more everyday language. In a study of tenth grade students, Hand, Hohenshell, and Prain (2004) found that the use of writing activities that incorporated planning was beneficial in helping student performance on a conceptual measure. Furthermore, two writing experiences were more beneficial than one when the students were tested two months after the writing experience. Jaubert and Rebiere (2005) discovered that primary school students' construction of science knowledge improved when using personal writing about science controversies. Hand, Hohenshell, and Prain (2007) showed that multiple, non-conventional writing-to-learn tasks significantly helped students learn, confirming that multiple writing tasks support effective student learning. Gunel, Hand & McDermott (2009) also found that embedded writing-to-learn activities help secondary school students gain conceptual understanding of scientific topics.

Further to these studies, Prain and Hand (1996) suggested a model for adapting writing-to-learn activities for science classrooms, which is framed around five critical elements ─ writing type, topic, purpose, method of text production, and audience. This interactive model provides different combinations of these five elements to develop a multitude of writing tasks to build conceptual understanding. The model provides a basis for teacher planning of student writing tasks, but it can also be used by students to plan and negotiate with teachers their own writing for learning in science (Prain & Hand, 1996). When using this framework, writers not only have to deal with content knowledge, but also take into consideration the various possibilities for representing this knowledge given the components of the writing task. Klein (2006) added sources as a sixth component to this model, pointing out that writers work from a knowledge source of some kind. Hand, Prain, Lawrence, and Yore (1999) outlined an implementation framework for writing in science that dealt with essential theoretical elements: the nature of science, epistemic ways of knowing, patterns of argumentation, plausible reasoning, big ideas of science, communications, and evidence. Collectively, these components and elements of writing within science classrooms move past the older, narrower conceptions of science literacy as merely reading and replicating science knowledge toward the combination of derived and fundamental senses of science literacy (Yore, Bisanz, & Hand, 2010).

The effective use of different writing forms to address specific purposes with various audiences is part of a fundamental sense of science literacy in which students are expected to "become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations" (National Research Council, 1996, p. 148). Different kinds of writing activities lead students to think about information in different ways and have different effects on learning (Langer & Applebee, 1987). Keys, Yang, Hand, and Hohenshell (2001) found learning gains for seventh grade students when they wrote for different readerships in varied genres on the topic of cells. Students in this program performed better on end-of-topic tests than students who had undertaken traditional writing tasks. Hildebrand (1999, 2004) showed that diversified writing tasks, including more imaginative writing, assisted students' learning processes, had strong motivating effects, and improved learning outcomes. Gunel, Akkus, Hohenshell, and Hand (2004) demonstrated that students' performance in answering higher-order cognitive questions was enhanced when they used a modified writing genre in contrast to students who wrote a traditional laboratory report, although the teacher's implementation strategies were viewed as a major factor in this outcome.

There is broad agreement about the importance of audience awareness. Attention to audience is a crucial component of all good writing. Effective writers develop an understanding that the language and content they use and create are interactive and that these must be taken into account by analyzing who their audience is (Engler, Raphael, Anderson, Anthony, & Stevens, 1991). When students write to a different audience other than a teacher, translation processes across various languages are required during writing-to-learn activities. Prain and Hand (2005) explained that in completing these types of writing, students engage in multiple translation processes among three languages; everyday language (home language), science language, and audience language. Students translate the science language into an everyday form of language that they can understand for themselves. They then translate the meaning they understand into an audience language to provide meaning and explanation for their audience. Students' awareness of the audience and its features will influence how this need is implemented in their writing. These translation processes require students to engage in content knowledge, frame writing according to the rhetorical elements required, and consider written discourse patterns used by the audience they are addressing (Gunel, Hand, McDermott, 2009). Rijlaarsdam, Couziijn, Janssen, Braaksma, & Kieft (2006) demonstrated that having students write to authentic audiences encourages cognitive processing that leads to greater learning, and their writing can provide teachers with a relatively easy means of intervention to improve science learning. In examining the impacts of different audiences on students' writing-to-learn activities, Gunel, Hand and McDermott (2009) found that students who wrote for their peers or for younger students performed significantly better on biology conceptual questions than students who wrote for their teacher or parents.

Several studies have attempted to provide evidence that explicit instruction for writing in science is necessary for students to accumulate the full benefit of writing for learning. For example, Moore (1993) found that college students' science achievement improved if writing was coupled with explicit writing instruction and embedded in actual science courses. Keys (1999) found that the majority of middle school students tended to write more lists of observation and description type clauses than inferential or explanatory clauses about authentic investigations when given no explicit writing instruction. Similarly, Campbell, Launda, Alli, Buffler, and Lubben (2000) showed that without explicit instruction in writing, students had vague and incomplete notions of appropriate report writing. In a study by Mason and Buscolo (2000), fourth grade students were explicitly taught the value of reflective journal writing and performed very well on tests of conceptual understanding. Conner (2000) found that secondary students valued heuristic scaffolds for writing essays in a bioethical context. Guided activities including questioning, a 'trash and treasure' activity for deciding on the relevancy of information, note-making, sorting, and peer review helped students gain a greater depth of understanding of science inquiry.

Acquiring Scaffolding Support

According to the genre-related hypothesis (Klein, 1999), writers elaborate their knowledge while wrestling with the demands of specific writing tasks, for instance, ones involving a particular type of text, defined purpose, or specific audience. A genre is a text structure with well-established discursive attributes, for instance, a narrative, description, or explanation (Rivard, 2004). This genre-based writing approach generally supports explicit instruction of the genre demands during writing and often includes well-defined guidelines or templates (Prain & Hand, 1996; Wray & Lewis, 1997). The use of teacher scaffolding and structured frames allow students to develop discourse knowledge about the specific genre (Yore, Bisanz, Hand, 2010). Keys (2994) has suggest that providing full writing strategy support, during which important characteristics of the writing are made explicit, might enhance students' performance. She found at ninth grade students who were provided scaffolding with report guidelines, collaborative discussions, and writing reports in pairs improved in summarizing relevant information from the textbook, using data and observations, and providing greater clarity in comparing and contrasting explanations. A study by Hand, Prain, and Wallace (2002) using the Science Writing Heuristic (SWH), a classroom tool for scaffolding the generation of knowledge from science investigations, and a letter-writing activity enhanced student performance on higher-level test items, but not on lower-level recall items. As Hand, Prain, Lawrence, and Yore (2000) emphasize, explicit writing tasks and instruction embossed in the authentic context of scientific inquiry should be provided as an integral part of science courses. Patterson (2001) believed that, when asking students to undertake writing tasks, there is a need to scaffold their attempts. In other words, students need to be provided with structured support and explicit instruction on how to transform their conceptual network into arguments and explanations.

Taken as a whole, in order for writing to be a successful learning tool for knowledge transformation, strategies should be embedded in learning (Yore et al., 2003). In addition, writing tasks in science should be linked with explicit instruction on an as-needed basis and encourage writers to write for an authentic audience; model scientific argumentation involving claims, evidence, and warrants; seek feedback; and revise their writing in light of feedback from their audience (Hand, Prain, Lawrence, & Yore, 1999).

The Use of Multiple Modes of Representation

There is growing research interest in the utilization of multiple modes of representing conceptual information (Gunel, Hand, & Gunez, 2006; Hand, Gunel, & Ulu, 2008; Pineda & Garza, 2000). Researchers stress that in order for students to learn science effectively, they must understand different representations of science concepts and processes and be able to translate these into another form of representation as well as understand their coordinated use in representing scientific knowledge. There is general agreement that students need to develop an understanding of diverse modes, rather than be dependent on particular modes for specific topics, if they are to develop a strong understanding of how to use and represent science concepts (Wallace, Hand, & Prain, 2007). diSessa (2004) suggested the need for a learner's meta-representational competence (MRC), arguing that this competency is more than just the "mere production and use of representations [but rather] stands as a free resource for further learning" (p. 294). By engaging their MRC students are able to build knowledge rather than simply recalling/regurgitating the approved representations supplied by textbooks. Dolin (2001) illustrated that senior secondary physics students achieved enhanced understanding of concepts in physics when they attempted to translate different representational modes into one another in that subject. Further, he asserted that this broader crossing between modes was essential for developing strong conceptual understandings. Pineda and Garza (2000) suggested that coming to an understanding of how the different modalities deal with the same concept involves a process of incremental inference constraints. They recommended that learners construct rich understandings of the language between modes through reasoning and inference, which is done through incremental steps.

By realizing that both the derived sense and the fundamental sense of literacy are critical to the development of scientific literacy, Hand (2008) expanded the definition of Norris and Phillips to include different modes of representation to the derived sense of science literacy. He argued that while this is implicit within reading and writing, there is a need to understand that different modes of science are critical to the concept of reading and writing. As Hand, Gunel, & Ulu (2009) asserted, complete conceptual understanding of a science concept (derived) and the ability to apply these ideas (fundamental) requires dealing with the multi-modal representations of that concept. Thus, multi-modal representations become important because language involves all forms of representations that are used within science. Gunel *et al.* (2006) broadened the objective of multi-modal usage by stressing a goal of not only translation of conceptual ideas by students in the context of the classroom, but also, ideally, translation through and with typical representational modes used in science.

As writing-to-learn activities for different audiences require translation processes across various communities of language, similarly, multimodal representation requires translation not only across different forms but also between all the modes used, that is, between the mathematical, graphical, pictorial, and text modes used (Gunel, Hand, Gundus, 2006). The transformation among multimodal representations has the greatest potential to promote learning and depth of processing (Yore & Hand, 2010). The embeddedness of representations, experience, argument, and printed words appears to be an indicator of successful integration of mental images, conceptual understanding, and stored meaningful knowledge. Embeddedness is least likely if the visual adjunct to printed words is decorative, more likely if it is representational or organizational, and required if it is interpretational or transformational (Carney & Levin 2002; Tippett, 2008). Studies investigating multi-modal representations in science writing recognize that requiring students to utilize modes other than text in their writing initiates a similar cognitive translation process for the author (Gunel et al., 2003; Hand et al., 2009).

Pineda and Garza (2003) explained a cyclical process of cognition resulting from the translation between multiple modes of representation proceeding until all possible connections to concepts are exhausted. Such explanation is similar to the dispositional dialectic of Galbraith's model. When applied to the context of writing tasks, an explanation for muti-modal representations parallels the cognitive process during writing in Galbraith's (1999) knowledge constitution model. Galbraith maintained that the production of text is one in which knowledge is constituted within a process of cycling through a network of content knowledge (dispositional dialectic) and linguistic knowledge. Each consecutive cycle is constrained by the number of connections that are made to the ideas being represented in the text until no more connections are possible within a learner's cognitive network. In line with this, given that multimodal representation is about representing knowledge in different language forms, translation between different modes of language will occur through a cyclic process until all connections have been exhausted, and the level of connections will be dependent upon each learner's conceptual framework (Gunel, Hand, & Gunduz, 2006).

Summary

The review above offers a theoretical framework that is the basis of this study. A framework to assess student writing and a method to interpret the findings was drawn from the studies in this literature review. The next chapter will describe the research methods and procedures of the study.

CHAPTER III

DESIGN AND METHODS

This chapter describes the design and methods utilized in this study. First, a justification for the method used in this study is provided. Next, the research context is described in terms of the Science Writing Heuristic (SWH) approach and the students' writing template. An overview of the research procedures, including explanation to the participants and data collection, is provided. Finally, the development of a framework for analysis and a description of the data analysis are summarized.

Research Method

A quasi-experimental design with a non-random sample from a middle school was used to address the research questions. A quasi-experimental design was appropriate for this study because of the use of convenience sampling rather than random sampling. As Creswell (2005) noted, it is not always possible for researchers to randomly assign participants to treatments of the independent variable in education studies. This study used a control group and treatment group, which were not randomly assigned. Kerlinger (1980) regarded the quasi-experimental design as a "compromise position" useful for research in education because the random assignment of students to treatment groups in school-like situations is impractical at best, and usually unfeasible in many cases. In education studies examining the impact of treatments to intact groupings of participants, the use of a quasi-experimental design is appropriate (Creswell, 2005).

Research Context

The Science Writing Heuristic (SWH) Approach

This study was situated within a Science Writing Heuristic (SWH) classroom context. The SWH developed by Hand and Keys (1999) is an argument-based inquiry approach incorporating the importance of both language use in learning and science argument into scientific inquiry (Keys, Hand, Prain, & Collins, 1999). In particular, the SWH approach integrates the disciplines of writing and reading during science investigations to create an authentic scientific inquiry environment in which dialogical interactions replace traditional didactic approaches (Hand, 2008). When the full sequences of the SWH approach are implemented, students are engaged in the whole process of scientific inquiry. By using a SWH approach, students are required to not only construct understanding, but also build their understanding around an argument (Hand, 2008). With a SWH approach, students are not told explicitly how to do the experiments, but rather, they are required to be more active in generating and answering questions. In a SWH approach, students are required to be involved in completing two distinct writing activities ─ the SWH templates during scientific inquiry activities and summary writing tasks at the end of unit. These are described below.

The Student Template of the SWH Approach

The SWH approach provides students with a heuristic template to guide science activity and reasoning in writing (Hand, 2008). The student template of the SWH is designed to help them construct scientific knowledge within a scientific inquiry (Keys, Hand, Prain, & Collins, 1999). The student template is a semi-structured writing form that scaffolds students' reasoning and facilitates meta-cognition about their investigations (Hohenshell & Hand, 2006). As shown in Table 2, the SWH template consists of seven phases.

Table 2. Phases of the Student Template for the Science Writing Heuristic (SWH) Approach

Phase			Questions Related to Phase
	Control group	Treatment group	
1	Beginning ideas	Beginning ideas	What are my questions?
2	Tests	Tests	What did I do?
3	Observation	Observation	What can I see?
4	Claims	Claims	What can I claim?
5	Evidence	Evidence	How do I know? Why am I making these claims?
6	Reading (the structured reading framework)	Reading (the original reading framework)	How do my ideas compare with others?
7	Reflection	Reflection	How have my ideas changed?

<u>Changing Phase 6: "How Do My Ideas Compare with Others?"</u>

In this study, the focus was on the reading phase ("How do my ideas compare with others?") of the SWH approach. In addressing this question, students are required to seek information from other various sources, such as textbooks, science magazines, journals, scientists, or through the internet, and are provided opportunities to make the connection between their ideas and the science ideas. It is important for students to understand that science argument is not just about their ideas but how their ideas compare to what is currently known and how they can align their views with current, accepted explanations (Hand, 2008). As part of the research project, the researcher constructed a more structured reading framework for this particular component of the reading framework.

The present study focused on the use of the reading framework, as a part of SWH student template, which is a structured reading framework guiding note-taking during the reading activity. While an original reading framework (see right figure2) has no guiding questions, the structured reading framework (see left figure2) has prompts such as source, information, and comparison. As shown in Figure 2, the reading framework includes guiding questions that students use as they read and write to reflect on what they have learned from the reading. The new structured reading framework is based on two critical stages. The first stage is centered on a more structured prompt to recording information from a source. The second stage is focused on requiring students to compare their recorded information to their claims and evidence, and their beginning ideas that they have previously generated. As a consequence the researcher believes that the reading phase allows students to negotiate with what they read from the various sources, and to sharpen their conceptual understanding of the big ideas of the unit.

< Reading framework> Notes from outside experts: (informational text, internet, encyclopedia, etc.)
Source : Author: Title:
Information: (What do I know from the source?)
How does the information from the source compare/contrast to my claim/evidence?

* Notes from outside experts (informational text, internet, encyclopedia, etc.)

Figure 2. Comparison of Two Reading Framework as a Part of the SWH Template Dearing with the Reading Phase; the Structured Reading Framework vs. the Original Reading Framework

The Summary Writing Task

The summary writing activity is the final activity within the unit in the SWH approach. In this study, the summary writing task was used as an assessment tool after students completed inquiry investigations using the SWH approach. The summary writing is intended to help students link together the conceptual ideas dealt with in the topic (Norton-Meier et al., 2008) and to incorporate all of the concepts about the topic at the end of the unit. A study by Gunel, Hand, and McDermott (2009) examining the impacts of different audiences on students' writing-to-learn activities indicated that students' writing that was focused on explaining science concepts to their peers performed significantly better on conceptual questions than students' writing for the teacher. Building on this research, students in this study are directed to write for a younger student as their audience. A diversified type of writing such as letter type or storybook type is often used.

Research Design

Participants

Students

For the purposes of this study, participating students were in grades 6-7 taught by two teachers in pre-existing classes in a middle school in Iowa, USA. The majority of students in this school were Caucasian (88.2%), followed by Hispanic (10%), Asian (0.6%), and African American (1.2%). The student gender breakdown of this middle school is 364 male and 357 female. A total of 170 students participated in the study, with 83 in the control group and 87 in the treatment group. A detailed breakdown of the groups of participants is provided in Table 3.

Table 3. Distribution of Student Participants in the Study

	Grade	Number of classes		Number of Students		
		Control	Treatment	Control	Treatment	Total
Teacher A	6th	2	2	37	40	77
Teacher B	7th	2	2	46	47	93
Total		4	4	83	87	170

Teachers

Two in-service science teachers participated in the study. Each of the two participating teachers taught grades 6 and 7 (see Table 3). For this study, each teacher was asked to randomly divide his/her classes into two control groups (SWH approach without reading framework) and two treatment groups (SWH approach with the reading framework). There were total of 4 control classes and 4 treatment classes in this study. Both teachers attended a 4-day summer workshop about implementing the SWH approach. During the workshop, they had the opportunity to explore the structure of the SWH approach within a professional development program. Further, since both teachers had not used the SWH approach previous to their participation in this study, the teachers were continuously supported with on-site professional development and on-line meetings using Skype in implementing the SWH approach. The researcher observed their classrooms regularly, had discussions with them, and provided them with continual feedback. In addition, the participating teachers were given guidance in designing and implementing the SWH approach. This prolonged interaction can be viewed as a potential limitation that may have influenced the study. However, more importantly, it was critical to maintain prolonged interaction between the participating teachers and the researcher because this study had to be conducted within the context of the SWH approach.

Research Procedure

This study was conducted between August 2010 and March 2011 and examined the impact of a structured reading framework embedded within the SWH student template compared to an original reading framework used within this template. The two teacher participants each taught four classes, with two classes using the structured reading framework (treatment) and two classes using the original reading framework (control). Both teachers taught two units using the SWH approach and followed the same general procedure in their classrooms. The teachers received in-service training prior to the implementation of the SWH approach that included discussion about the progression of lessons, information about the writing tasks and assessments, and information about the research study in general. The teachers then implemented the study procedures in their classrooms.

The use of students in different grades and teachers with different philosophies, experiences, and practice can be viewed as a confounding variable that may impact implementation. However, the intent of this study was to examine the impact of the structured reading framework within the SWH approach in a middle school setting. Therefore, if the use of this method can be shown to be beneficial in these settings, regardless of grade level and the individual teacher teaching them, evidence for the implementation of the structured reading framework within the SWH approach is enhanced. From this perspective, the use of students from different grades and different teachers are considered useful characteristics.

The prior year's science scores on The Iowa Tests of Basic Skills (ITBS) of all students were used as the baseline test. Science is one of the subject areas that the ITBS covers, and targets knowledge and skills of content areas such as life science, earth and space sciences, and physical sciences. In addition, students are also required to use the concepts and principles of science to explain, infer, hypothesize, measure, and classify. Thus, ITBS science score was utilized as a general measure of students' science ability. Mann-Whitney *U* test was used to detect differences between two groups with respect to their the ITBS science scores. A significant difference at $p < .05$ was detected between the treatment and control group.

All four classes of each teacher participated in the SWH approach. As shown in Table 2, all students used the SWH student templates to guide their written work and completed the SWH student templates during the SWH investigations of each unit. As shown in Appendix A, the only difference between the treatment group template and control group template was the reading section. The control group had an original reading framework for the reading phase, while the treatment group had a structured reading framework. After completing the SWH investigations, both groups of students were asked to complete the summary writing task at the end of each unit which focused on integrating concepts from the unit and were directed to write for a younger audience. This process was replicated after each of the two units, where all students completed several SWH templates during multiple investigations and two summary writing tasks over the two units. The overall research procedure is summarized in Table 4. In this study, the variable of time was controlled such that the teachers discussed appropriate timelines for each unit and for each writing activity prior to the start of the study.

Table 4. Overall Research Procedure and Data Collection Time Points

Control group	Treatment group	Time line
Baseline test (ITBS)	Baseline test (ITBS)	Aug.
⇩	⇩	
SWH classroom (Original reading framework)	SWH classroom (Structured reading framework)	Nov.
⇩	⇩	
Summary writing for unit 1	Summary writing for unit 1	Dec.
⇩	⇩	
SWH classroom (Original reading framework)	SWH classroom (Structured reading framework)	Feb.
⇩	⇩	
Summary writing for unit 2	Summary writing for unit 2	Mar.

Data Collection

Data collection took place over the two units during two semesters. Two main data sources were collected. First, all students' templates of the SWH were collected after each unit. Second, the student summary writing samples were collected after completion of the writing task at the end of each unit. The actual number of student writing samples collected varied over the two units, as shown in Table 5. Initially, a total of 223 students volunteered to provide their writing samples, but the number of writing samples collected within each unit by class period, unit, and grade level varied because of factors related to attendance and failure to complete the activities. In total, 896 students' writing samples were collected and scored. However, to maintain uniformity and consistency, only 588 writing samples over two units were included in the statistical analysis. For this reason, although all students' writing samples that were collected were scored, not all were included in the statistical analysis (see Table 5).

Table 5. The Number of Student Writing Included in the Statistical Analysis

	SWH Template	Summary Writing	Total Number of Student Writings
Unit 1	141	158	299
Unit 2	135	154	289
Total	276	312	588

Development of Frameworks for Analyzing Student Writings

This section describes the development of the frameworks for analyzing the student writings of both the reading framework and summary writing.

Analytical frameworks were developed to evaluate the reading framework section of the SWH template and the summary writing samples produced by the students. Analytical frameworks for evaluating the student writing samples for the two units were developed and informed by an analysis of student writing samples from separate pilot studies conducted in Korea and U.S. Examining these students' writing samples and relevant literature provided an important opportunity to brainstorm and elaborate on ideas for criteria of the analytical framework and the scoring matrix. They were further revised based on feedback from a professor and research assistant in science education. All students' writing samples were then evaluated using the developed analytical frameworks and scoring matrices.

Analytical Framework for the Reading Framework

The analytical framework for the reading framework includes three components: the use of information, the quality of comparison, and the number of different modes used. The criteria established for the Reading Framework score are presented in Table 6 and the scoring matrix is shown in Table 7.

Using the scoring matrix for the reading framework presented in Table 7, each writing sample was scored on the three main components. As shown in Table 6, the first main component was assessed using a scale ranging from 0-1 and 0-3 for each sub-component (credibility of information, connection of information to the big idea). The two combined sub-component scores are referred to as the "use of information" score. The second component of quality of comparison involves two sub-components, each scored on a scale from 0-3. Their combined core is referred to as the "quality of comparison" score. Finally, the "number of modes" score was the overall number of modes utilized. This assessment involved a count of the total number of different types of modal representations used. Students who did not write anything earned no points for that particular component. The Total Reading Framework score is the sum of the three main component scores.

Table 6. Analytical Framework to Evaluate the Reading Framework

Component	Criteria	Score Scale
Use of Information	• Is the information from the source credible?	0-1
	• Is information from the sources related to the question/big idea proposed by students?	0-3
Quality of Comparison	• Do students recognize what/how information is similar/different to their claim & evidence/beginning idea?	0-3
	• Is the comparison accurate and adequate?	0-3
Number of Modes	• How many different modes do students use?	Number Count

Table 7. The Scoring Matrix for the Reading Framework

Component	Subcomponent	Score	
Use of Information	Credibility	0	The information from source is not credible
		1	The information from source is credible
	Connection to Big idea	0	No relationship between the information from the sources and big idea
		1	The information from the source is weakly related to the big idea
		2	The information from the source is related to the big idea
		3	The information from the source is strongly related to the big idea
Quality of Comparison	Connection to Claim & evidence	0	No connection between the comparison and claim & evidence
		1	Weak connection between the comparison and claim & evidence
		2	Moderate connection between the comparison and claim & evidence
		3	Strong connection between the comparison and claim & evidence
	Accuracy of Comparison	0	Inaccurate and invalid comparison
		1	Weakly accurate and valid comparison
		2	Accurate and valid comparison
		3	Sophisticated and strongly valid comparison
Number of Mode		Number count	

Analytical Framework for the Summary Writing Task

The analytical framework for the summary writing includes five components: quality of content, number of modes, cohesiveness, accuracy, and audience. The criteria established for the summary writing score are presented in Table 8 and the scoring matrix is shown in Table 9.

As shown in Table 8, "quality of content" was assessed using a scale from 0-3. This component is associated with students' conceptual knowledge. Next, the overall "number of modes" utilized was scored. This involved a count of the total number of different types of modal representations used. In addition, recognition is given to text as a mode, and thus one point was given to the written text only. Three points was assigned when three different types of modal representations were utilized, for example, one pictures and one symbol including text. The third component of "cohesiveness" among modes was scored on a scale from 0-3. The key for scoring this component was whether or not the modes were connected to each other. In other words, when more than two modes were used throughout the writing, cohesiveness was evaluated by considering how well the modes were explained, "unpacked", and contextualized in the text. The fourth component, "accuracy" of mode, was also scored on a scale from 0-3. Accuracy was evaluated separately from cohesiveness. For example, a student may have sophisticated and accurate modes, but the modes utilized may not be explained in the text and connected to each other. In this case, the student would be given a high score for component, but a low score for cohesiveness. Finally, the component of "audience" was evaluated on a scale from 0-2 as to whether or not the student writing is well targeted to the audience. The total summary writing score is the sum of the five component scores.

This scoring process, which generated a reading framework score and a summary writing score for each writing sample, was performed at least twice. The process continued for several months until two consecutive iterations resulted in the same score.

Table 8. The Analytical Framework to Evaluate the Summary Writing Task

Component	Criteria	Score Scale
Quality of Content	• How well do students explain the concept logically?	0-3
Number of Modes	• How many different modes do students use to reflect their idea?	Number Count
Cohesiveness	• How well are modes connected to each other?	0-3
Accuracy	• Are modes valid or accurate?	0-3
Audience	• Is the writing accurate for the audience?	0-2

Table 9. The Scoring Matrix for the Summary Writing Task

Component	Score	
Quality of Content	0	No explanation
	1	Weak explanation of the concept
	2	Moderate explanation of the concept
	3	Strong explanation of the concept
Cohesiveness	0	No cohesiveness
	1	Weak cohesiveness/connection between modes
	2	Moderate cohesiveness /connection between modes
	3	Strong cohesiveness /connection between modes
Accuracy	0	Inaccurate mode representation
	1	Weakly adequate mode representation
	2	Adequate mode representation
	3	Sophisticated mode representation
Audience	0	Writing is inappropriate to audience
	1	Writing is appropriate to audience
	2	Writing is well targeted to audience
Number of Mode	Number count	

Reliability of Analytical Framework

The internal consistency was determined for all components of the reading framework and the summary writing using Cronbach's alpha and calculated at .787 for the reading framework, and .880 for the summary writing.

Inter-rater reliability of scoring using the analytical framework was measured by Pearson's correlation coefficient. Two raters independently performed the scoring scored 70 randomly selected students' writing samples from their SWH templates and summary writings. One of the raters was the researcher of this study and the other rater was a doctoral student in science education who did not participate in the study. Two evaluators worked together on eight of the student writing samples to coordinate the way to apply the analytical framework. Whenever there was more than a one-point difference in the reported scores, they discussed the discrepancy until resolution. Pearson's correlation coefficients were used to measure the inter-rater reliability of scoring using the analytical framework. Pearson's correlation coefficients for each component of the reading framework and the summary writing are shown in Table 10.

Table 10. Correlation Coefficients for Inter-Rater Reliability

	Component	*r*
Reading Framework	Use of Information	.928
	Quality of Comparison	.966
	Number of Mode	1.000
	Total Reading Framework	.975
Summary Writing	Quality of Content	.854
	Number of Mode	1.000
	Cohesiveness	.836
	Accuracy	.838
	Audience	.904
	Total Summary Writing	.978

Data Analysis

Using the reading framework of SWH template and summary writing scores generated through the scoring process described in the previous section, the analyses were conducted. Each raw score for the components of the reading framework and the summary writing was converted into a Z-score because those scores are from different scales. A weighted composite of Z-score for each component was created and the Z-composites were used for the ANCOVA and the partial correlation analysis. Data analyses were carried out using the Statistical Package for Social Science (SPSS) for Windows, Version 19.0.

Analysis of Covariance (ANCOVA)

A two way ANCOVA was designed to determine whether the group using the structured reading framework within the SWH approach compared to a control group was significantly different on the summary writing. The covariate was included to adjust for possible incoming achievement differences among the intact classes in the study. The ANCOVA method was used to test for differences between group, grade and all interactions among these factors. The summary writing total score was used as the dependent variable, and ITBS science score as the covariate. Statistical significance was determined at an alpha level of .05 for statistical tests.

Effect Size Calculations

Effect size calculation was considered for the comparison of the two groups. Effect size calculations are often used in educational research because they provide a practical meaning of group differences that may or may not be captured by simple significance tests. Additionally, an effect size calculation is useful in that it provides a measure of the magnitude of differences between groups. Effect size can provide this information about differences between any two groups even if no statistically significant differences are found. According to Cohen (1992), the criteria for identifying the magnitude of an effect size is as follows: A *trivial* effect size is below 0.2; a *small* effect size is between 0.2 and 0.49; a *medium* effect size is between 0.5 and 0.79 and a *large* effect size is one that is 0.8 or greater.

Correlation Analysis

Partial correlation controlling for the ITBS science score was carried out to determine the degree of relationship between each of the three components of the reading framework including total score and each of the seven components of the summary writing, including total score. The relationship among the components of the reading framework and the summary writing was also examined.

Summary

The methods and data analysis used in this study were developed to help provide an accurate interpretation as possible of the study results. Two analytical frameworks for the reading framework of the SWH template and the summary writing were developed to evaluate students' writings. Student writing samples were assessed using the scoring matrix based on these frameworks. Results from these procedures are reported in the next chapter, followed by a discussion of the results.

CHAPTER IV

RESULTS

In this chapter, the research questions are answered in the order they were posed. First, whether the treatment group which used the reading framework embedded in the SWH template performed better on the summary writing task compared to the control group was determined. Next, the effect sizes between the two groups were examined. Then, using partial correlation analysis controlling for the ITBS science score, relationships among the components of the reading framework and the summary writing task were explored. Finally, a summary of the overall findings is presented.

Group Differences on the Summary Writing Task

To evaluate if there was an initial difference between the two groups on the ITBS science score utilized as a baseline test prior to initiation of the treatment for the study, a Mann-Whitney *U* test was conducted, as described in the methods section. The result indicated that there was a significant difference between two groups on the ITBS science score ($z = -2.01$, $p = .045$). The treatment group had an average rank of 107.43 while the control group had an average rank of 91.08. Due to this significant difference, the ITBS science score was used as a covariate when assessing the students' summary writing scores. To determine if the total score on the summary writing task was greater in the treatment group compared to the control group after controlling for grade and ITBS score, an analysis of covariance (ANCOVA) was performed. The total score of the summary writing task was used as the dependent variable, group (treatment and control) and grade as fixed factors, and the ITBS science score as a covariate.

Table 11 illustrates the descriptive statistics for all raw scores as well as for Z-score composites of the total summary writing score, in which the treatment group (Mean = -.92, SD = 3.77) scored higher than the control group (Mean = -2.76, SD = 3.32) in sixth grade. Similar findings were seen in seventh grade, where the treatment group (Mean = 2.39, SD = 4.64) outperformed the control group (M = .58, SD = 2.64).

Table 11. Descriptive Statistics for the Total Summary Writing Score by Grade and Group

Grade	Group	N	Raw Score		Z-score	
			Mean	SD	Mean	SD
6	Control	37	9.27	4.85	-2.76	3.32
	Treatment	40	11.90	5.53	-.92	3.77
	Total	77	10.64	5.35	-1.81	3.65
7	Control	46	14.33	3.89	.58	2.64
	Treatment	47	16.91	6.82	2.39	4.64
	Total	93	15.63	5.69	1.50	3.87
Total	Control	83	12.07	5.00	-.91	3.38
	Treatment	87	14.61	6.71	.86	4.55
	Total	170	13.37	6.06	.00	4.11

The result from the ANCOVA indicated a significant difference in the total summary writing score between the treatment group, which used the reading framework (Mean = .86, SD = 4.55) and the control group, which used the original reading framework (Mean = -.91, SD = 3.38). As shown in Table 12 and 13, there were significant main effects for the group ($F(1, 165) = 4.84$, $p = .03$), and for the grade ($F(1, 165) = 35.51$, $p < .0001$). The ANCOVA result did not change in any important way when the analysis with the raw score composites was conducted.

Table 12. ANCOVA Results for the Total Summary Writing Score by Grade and Group

Source	SS	df	MS	F	p-value
Overall Model	861.44	4	215.36	17.84	< .0001
ITBS SC	262.53	1	262.53	21.74	< .0001
Grade	428.81	1	428.81	35.51	< .0001
Group	58.42	1	58.42	4.84	.03
Grade * Group	.23	1	.23	.02	.89
Error	1992.26	165	12.07		
Total	7076.55	169			

Table 13. Adjusted Means by Grade and Group

	Group		Grade	
	Control	Treatment	Sixth	Seventh
N	83	87	77	93
Adj. Mean	-.77	.44	-1.76	1.43

Effect Size Calculations

The effect size differences of the total summary writing scores were calculated between the treatment and control groups using the Cohen *d* index. The effect sizes of the treatment group using the Structured Reading framework compared to the control group was medium in sixth grade (Cohen's $d = .52$) and small in seventh grade (Cohen's $d = .33$). Regardless of grade level, using the structured reading framework resulted in a small effect (Cohen's $d = .38$) when compared to those who used the original Reading Framework.

Abbreviations Utilized

Table 14 references the abbreviations used throughout this chapter in describing the components of the reading framework and the summary writing tasks.

Table 14. Abbreviations of the Reading Framework and the Summary Writing Components

Abbreviation		Explanation
Reading Framework	UI	Use of Information
	QC	Quality of Comparison
	NM	Number of Modes
	RF	Reading Framework
Summary Writing Task	QCSW	Quality of Content
	NMSW	Number of Modes
	CSSW	Cohesiveness
	ACSW	Accuracy
	ADSW	Audience
	SW	Summary Writing

Relationships among the Components of the Reading Framework and the Summary Writing Task

The second research question examined: 1) the relationship among the components of the reading framework, 2) the relationship between the components of the reading framework and summary writing task, and 3) the relationship among the components of the summary writing task. Partial correlation controlling for the ITBS science score was used and the correlation between the total reading framework and summary writing score and each of their component scores were investigated at the group level and reported in this section. Table 15 provides the descriptive statistics of the partial correlations overall and by group for raw scores as well as for Z-score composites.

Table 15. Descriptive Statistic of the Partial Correlation Analysis

	Total			Treatment			Control		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
UI	170	3.32 (.00)	2.30 (1.00)	87	4.04 (.31)	2.18 (.95)	83	2.57 (-.33)	2.19 (.95)
QC	170	1.32 (.00)	2.01 (1.00)	87	2.54 (.61)	2.18 (1.09)	83	.04 (-.64)	.24 (.12)
NM	170	1.36 (.00)	.71 (1.00)	87	1.43 (.09)	.68 (.95)	83	1.30 (-.09)	.74 (1.05)
TOTAL RF	170	6.01 (.00)	4.28 (2.50)	87	8.01 (1.01)	4.50 (2.62)	83	3.91 (-1.05)	2.79 (1.86)
QCSW	170	3.17 (.00)	1.42 (1.00)	87	3.48 (.22)	1.49 (1.04)	83	2.84 (-.23)	1.28 (.90)
NMSW	170	3.81 (.00)	1.37 (1.00)	87	3.99 (.13)	1.44 (1.05)	83	3.61 (-.14)	1.28 (.93)
CSSW	170	1.94 (.00)	1.54 (1.00)	87	2.26 (.21)	1.75 (1.14)	83	1.60 (-.22)	1.20 (.78)
ACSW	170	2.79 (.00)	1.72 (1.00)	87	2.92 (.08)	1.80 (1.04)	83	2.65 (-.08)	1.64 (.95)
ADSW	170	1.66 (.00)	1.29 (1.00)	87	1.95 (.22)	1.34 (1.04)	83	1.36 (-.24)	1.16 (.90)
TOTAL SW	170	13.37 (.00)	6.06 (4.11)	87	14.61 (.86)	6.71 (4.55)	83	12.07 (-.91)	5.00 (3.38)

Note: The descriptive statistics (means and SDs) for Z-score composites were reported in parentheses.

Relationship among the Components of the Reading

Framework Including the Total Reading Framework Score

As shown in Appendix B, for the overall group, the correlation among the Total Reading Framework scores and each component scores of Reading Framework ranged from .302 to .916 and all the values were significant at the .01 level.

To investigate the degree of the relationship at the group level, a partial correlation analysis controlling for the ITBS science score was carried out separately for the treatment and control groups (Table 16). For the treatment group, significant correlations were found among the component scores and the total Reading Framework score. In particular, for the treatment group, Quality of Comparison (QC) was highly correlated with Use of Information (UI) (partial r = .652, p< .01) and also highly correlated with the Total Reading Framework (TOTAL-RF) score (partial r = .838, p< .01). In contrast, no significant correlations between QC and each of the other scores were found in the control group. The partial correlation results did not change in any important way when the analysis with the raw score composites was conducted.

Table 16. Partial Correlations among the Component Scores of the Reading Framework Including the Total Reading Framework Score by Group

	Treatment Group			Control Group		
	UI	QC	NM	UI	QC	NM
QC	.652**			.025		
NM	.768**	.502**		.733**	-.054	
TOTAL RF	.918**	.838**	.858**	.925**	.047	.933**

**. Correlation is significant at the .01 level (2-tailed)

Relationship among the Components of the Reading

Framework and the Summary Writing Task

As shown in Appendix B, for the overall group, correlation among the each component scores the Reading Framework and Summary Writing ranged from .206 to .501 and all the values were significant at the .01 level.

Table 17. Partial Correlations among the Components of the Reading Framework and the Summary Writing Task by Group

	Treatment				Control			
	UI	QC	NM	TOTAL RF	UI	QC	NM	TOTAL RF
QCSW	.517**	.337**	.456**	.497**	.320**	.277*	.318**	.360**
NMSW	.282**	.255*	.248*	.300**	.304**	-.013	.467**	.417**
CSSW	.396**	.404**	.380**	.453**	.204	.093	.413**	.342**
ACSW	.330**	.348**	.300**	.376**	.295**	-.050	.353**	.346**
ADSW	.450**	.323**	.424**	.455**	.251*	.260*	.245*	.283**
TOTAL SW	.468**	.397**	.429**	.494**	.375**	.145	.485**	.474**

**. Correlation is significant at the .01 level (2-tailed)

*. Correlation is significant at the .05 level (2-tailed)

Note: The partial correlation results did not change in any important way when the analysis with the raw score composites was conducted.

To examine the degree of the relationships at the group level, the partial correlation analysis controlling for ITBS science score was performed for the treatment and control groups separately (Table 17). The correlations in the treatment group tended to be higher than in the control group. For the treatment group, all correlations were significant. In particular, for the treatment group, the correlation between the Use of Information (UI) component score of reading framework and Quality of Comparison (QCSW) component score of summary writing is higher than the relationships with components (partial $r = .517$, $p < .01$). And it was also higher than in the control group. Further, for the treatment group, the correlation between the Quality of Comparison (QC) component score of reading framework and Cohesiveness (CSSW) component score of summary writing is higher than other relationships (partial $r = .404$, $p < .01$). In contrast, for the control group, the Quality of Comparison component score was not correlated with other component scores of summary writing, or very weakly correlated. It was also lower than in the treatment group. In particular, while the QC component score of reading framework was significantly positively correlated with Total Summary Writing (TOTAL SW) score in the treatment group (partial $r = .397$, $p < .01$), no significant correlation between the two component scores was found in the control group.

Relationship among the Components Scores of Summary Writing Including the Total summary writing Score

Overall, the correlation among the total summary writing score and each component score of the summary writing task ranged from .333 to .856, with all values significant at the .01 level (see Appendix B).

When compared to control group, the significant correlation among the each components scores of Summary Writing tended to be higher in the treatment group. In particular, as shown in Table 18 and Table 19, the Audience (ADSW) component score of the summary writing in the treatment group was strongly correlated with Total

Summary Writing score (partial *r* = .814, p < .01), and the correlation between them was higher than in the control group. Furthermore, for the treatment group, the correlation of the ADSW component score with CSSW, NMSW, and ACSW components was high enough to be statistically significant at the .01 level (i.e., partial *r* = . 628 for CSSW, partial *r* = .482 for NMSW, partial *r* = .555 for ASCW, p < .01). In contrast, for the control group, the correlations between ADSW and the other component scores were not significant. In addition, the correlation of total summary writing sore and ADSW was relatively lower compared to other components, although it was statistically significant.

Table 18. Partial Correlations among the Summary Writing Component Scores Including Total Summary Writing Score for the Treatment Group

	QCSW	NMSW	CSSW	ACSW	ADSW
NMSW	.577**				
CSSW	.583**	.717**			
ACSW	.585**	.743**	.769**		
ADSW	.771**	.482**	.628**	.555**	
TOTAL SW	.831**	.832**	.881**	.864**	.814**

**. Correlation is significant at the .01 level (2-tailed).

Note: The partial correlation results did not change in any important way when the analysis with the raw score composites was conducted.

Table 19. Partial Correlations among the Summary Writing Component Scores Including Total Summary Writing Score for the Control Group

	QCSW	NMSW	CSSW	ACSW	ADSW
NMSW	.451**				
CSSW	.397**	.726**			
ACSW	.373**	.767**	.680**		
ADSW	.610**	.095	.183	.058	
TOTAL SW	.761**	.830**	.798**	.791**	.518**

**. Correlation is significant at the .01 level (2-tailed)

Note: The partial correlation results did not change in any important way when the analysis with the raw score composites was conducted.

Summary

In terms of the Summary Writing Task performance, the ANCOVA result shows a significant difference in the total Summary Writing scores between the two groups. The group using the Structured Reading Framework within the SWH approach performed significantly better than the control group using the original Reading Framework on the Summary Writing task. The results of the effect size calculation also show that by grade, there was a medium effect size for grade 6 and a small effect size for grade 7.

In terms of the relationship among the components scores of the Reading Framework, for the treatment group, the Quality of Comparison component score was highly correlated with the Use of Information component score. In contrast, there were no significant correlations between Quality of Comparison and any of the other Reading Framework component scores in the control group.

In terms of the relationship among the components scores of the Reading Framework and the Summary Writing task, overall correlations in the treatment group tended to be higher than in the control group. While all correlations in the treatment group were significantly positive, for the control group, the Quality of Comparison component score of the Reading Framework was either not correlated or very weakly correlated with any component scores of the Summary Writing. In particular, while the Quality of Comparison component score of the Reading Framework was significantly positively correlated with the total Summary Writing score and Cohesiveness component score of Summary Writing in the treatment group, no such significant correlation between them was found in the control group. In addition, for the treatment group, the correlation between the Use of Information component score of the Reading Framework and Quality of Content component score of the Summary Writing was higher than the relationships with other components of the Summary Writing, and it was also higher than in the control group.

In terms of the relationship among the components scores of the Summary Wiring including total Summary Writing Score, the significant correlations in the treatment group tended to be higher than control group. In particular, the Audience component score of the Summary Writing task in the treatment group strongly correlated with the total Summary Writing score, and this correlation was higher than in the control group. Furthermore, the correlations of the Audience component score with the components of Cohesiveness, Number of Modes, and Accuracy of the Summary Writing task were positively significant in the treatment group, but were weak or non-existent in the control group.

CHAPTER V

DISCUSSION

In this chapter, answers to the research questions are summarized, followed by a discussion of the results. Furthermore, some potential implications of this research and suggestions for further research are provided while acknowledging limitations of this research.

Answers to Research Questions

Research Question 1

Is there a difference between using the Structured Reading Framework and the original Reading Framework within the SWH approach on the Summary Writing task?

The first research question examined whether use of the Structured Reading Framework within the SWH approach led to measurable differences on the Summary Writing task. Results revealed a significant difference in the total Summary Writing scores between the two groups. Regardless of grade level, the treatment group who used the Structured Reading Framework within the SHW approach performed significantly better on the Summary Writing task than the control group who used the regular SWH template.

Effect size differences for the total Summary Writing scores were calculated between the two groups. The treatment group resulted in a small effect when compared to the control group. By grade, there was a medium effect size for grade 6 and a small effect size for grade 7.

Research Question 2

To investigate the degree of relationship between the Reading Framework and the Summary Writing task for each group, separate correlation analyses were performed. The second research question addressed three relationships: the relationship among the component scores of the Reading Framework, the relationship between the component scores of the Reading Framework and the total Summary Writing score, and the relationship among the component scores of the Summary Writing task. The following discussion focuses on a comparison of the treatment and control groups.

2-1. Relationship among the Components Scores of the Reading Framework Including the Total Reading Framework Score

For the treatment group, all correlations were significant among the components scores of the Reading Framework and including the total Reading Framework score. In particular, for the treatment group, the Quality of Comparison component score was highly correlated with the Use of Information component score. In contrast, there were no significant correlations between Quality of Comparison and any of the other Reading Framework component scores in the control group.

2-2. Relationship among the Components Scores of the Reading Framework and the Summary Writing Task

Overall, correlations in the treatment group tended to be higher than in the control group. While all correlations in the treatment group were significantly positive, for the control group, the Quality of Comparison component score of the Reading Framework was either not correlated or very weakly correlated with any component scores of the Summary Writing. In particular, while the Quality of Comparison component score of the Reading Framework was significantly positively correlated with the total Summary Writing score and Cohesiveness component score of Summary Writing in the treatment group, no such significant correlations between them were found in the control group. Further, for the treatment group, the correlation between the Use of Information component score of the Reading Framework and Quality of Content component score of the Summary Writing is higher than the relationships with other components of the Summary Writing, and it was also higher than in the control group.

2-3. Relationship among the Components Scores of the Summary Wiring Including Total Summary Writing Score

When compared to the control group, the significant correlations among the component scores of the Summary Writing task tended to be higher in the treatment group. In particular, the Audience component score of the Summary Writing task in the treatment group strongly correlated with the total Summary Writing score, and this correlation was higher than in the control group. In addition, the correlations of the Audience component score with the components of Cohesiveness, Number of Modes, and Accuracy of the Summary Writing task were positively significant in the treatment group, but were weak or non-existent in the control group.

Discussion of Results

Before discussing the results, the researcher would like to reiterate that this study would discuss about the students' writing, rather than their reading, that occurs within the Reading Framework. The intention of the Reading Framework in this study was to prompt students to use information from their reading. By emphasizing that the Reading Framework, which is looking at the written product, is the writing, not the reading, the researcher would argue the constitutive nature of writing.

Group Differences on the Summary Writing Task

The purpose of this research was to determine the impact of an embedded Structured Reading Framework compared to the original Reading Framework within the

SWH approach on students' conceptual understanding, as measured by the Summary Writing task. The treatment group performed significantly better than the control group on the Summary Writing task, which helps students link together the conceptual ideas dealt with in the topic. The effect size differences indicated that students who utilized the Structured Reading Framework within the SWH approach developed better conceptual understanding as measured by the Summary Writing task. This result supports the finding by Hohenshell and Hand (2006), who also showed the benefit between the SWH and the Summary Writing task. Given that all students had the same time on tasks, the value of using the Structured Reading Framework can then be seen as important precursor to developing conceptual understanding in their Summary Writing task.

In sum, the results suggest that the using of the Structured Reading Framework prompting and guiding reading activity within the SWH approach have an impact on the development of conceptual understanding.

Comparisons of the Relationships among the Components Scores of the Reading Framework and the Summary Writing Task

The second question aimed to understand the relationship between the components of the Reading Framework and the development of conceptual understanding in the Summary Writing task relative to cognitive processes.

While it is understood that a significantly positive correlation is not indicative of a causal relationship, it is evidence that a positive relationship exists between the variables.

These results provide possible evidence to support the ANCOVA result discussed earlier, and to explain why there is a difference between the two groups on the Summary Writing task.

Relationship among the components scores of the Reading Framework including the total Reading Framework Score

In the treatment group, the Quality of Comparison component of the Reading Framework was significantly and highly correlated with the Use of Information component of the Reading Framework. In contrast, there was no significant correlation between these two components in the control group. The Use of Information component score indicates how well students use credible information and how well the information from the reading sources is connected to the big idea and their claims and evidence. The Quality of Comparison score reveals how well students compare and contrast information from the reading source with their previous understanding and their own claims and evidence. Therefore, the correlation between these two components suggests that the better information students have, the better they are able to compare their previous knowledge with new scientific knowledge they have just read. Stated differently, a good job in gathering information helps students make comparisons.

As described in Chapter III, the structured Reading Framework for treatment group that is more structured prompt is designed for two stages task. The prompts used in the Structured Reading Framework require the students to engage in two tasks. The first is a series of prompts to record information to help students gather information from various sources, such as textbooks, magazines, and Internet sources. The second prompt requires them to compare that information with their claims and evidence, and beginning ideas. While these prompts are structured, they are not so highly structured that they do not enable students some freedom to complete the task. The intent of the Structured Reading Framework is to guide students to examine their previous ideas in relation to their claims and evidence, and then constitute new scientific knowledge from various information sources. It is speculated that these two tasks require different processing demands. While the first prompt is a knowledge-gathering process, the second prompt is a comparison, which is a knowledge constitutive process. The first part, which is the information gathering, is not as cognitively demanding as making comparisons. The researcher would suggest that the comparison prompt promotes a constitutive process in that students have to go backward to their beginning idea and their own claims and evidence and then go forward to coordinate this with information gathered from the first prompt in order to answer the second prompt. The result of this study reveals that while these two stages were positively related to one another in the treatment group, no relationship was evident in the control group. The two groups differed in terms of how they used information in the Reading Framework. It appears that students in the control group who used the regular Reading Framework engaged in knowledge-gathering activities, but did not complete a comparison activity and, thus, struggled to make a connection between the new knowledge gathered from the sources with their own ideas. In contrast, it appears that students who used the Structured Reading Framework engaged in a more knowledge constitutive activity. In essence, the Reading Framework itself does not appear to establish strength in the relationship between information gathering and comparison. That is, the lack of prompts in the original Reading Framework may not to build the strong positive relationship. On the other hand, the Structured Reading Framework that include the stage that asks students to compare what they read from the sources to what they previously constructed before appears to scaffold students' a knowledge constitutive activity in students, thus promoting a stronger relationship between these two activities.

Relationship among the Component Scores of the Reading Framework and the Summary Writing Task

The correlations in the treatment group tended to be higher than in the control group. While all correlations in the treatment group were significantly positive, the Quality of Comparison component score of the Reading Framework was not correlated, or weakly correlated, with the other component scores of the Summary Writing task in the control group. It can be argued that Quality of Comparison is critical to complete the Summary Writing task. The Summary Writing task is intended to assist students to link together conceptual ideas dealt with in the topic (Norton-Meier et al., 2008), and to incorporate all concepts about the topic at the end of the unit. In this regard, the correlation between the Quality of Comparison component and the components of the Summary Writing task implies a relationship between how well students compare scientific knowledge from what they have read with their prior constructed knowledge and the development of conceptual understanding in the Summary Writing task. Moreover, considering that students who used the Structured Reading Framework were able to develop better conceptual understanding in their Summary Writing task than those who used the original Reading Framework, it can be suggested that the Structured Reading Framework promoted the ability to compare, resulting in the development of conceptual understanding.

In particular, while the Quality of Comparison component score of the Reading Framework was significantly and positively correlated with the Cohesiveness component score of the Summary Writing task in the treatment group, this was not seen in the control group. This comparison task requires students to analyze and synthesize how their new knowledge and previous knowledge fit together. Cohesiveness represents how well the modes utilized by students tie together as an explanation in the Summary Writing task. As Seufert (2003) asserted, deep conceptual understanding in science is only truly realized when students are able to produce connections both within and between different representations. Given that Cohesiveness is viewed to be critical in the development of multimodal representation competency, this relationship can be interpreted to mean that the cognitive process of comparison is related to developing multimodal representation competency. Further, while this relationship was significant in the treatment group, no relationship was found in the control group. In this regard, when considering that the treatment group performed better than control group for the Summary Writing, the researcher would suggest that the Structured Reading Framework provided significant support structure in developing multimodal representation competency.

On the other hand, regardless of the treatment condition, the correlation between the Use of Information component score of the Reading Framework and the Quality of Content component score of the Summary Writing task was higher than the relationships with the other Summary Writing components. The Quality of Content component is related to science content knowledge. Use of information related to the knowledge gathering process appears to be more associated with content knowledge rather than rhetorical knowledge. In addition, the result suggests that if students use more credible information, and more connected the big idea, they provide better science content knowledge in their Summary Writing tasks, regardless of which reading framework (structured or original) they used. Given that use of the information is related to knowledge gathering, this relationship is expected. However, this relationship was higher in the treatment group than the control group, inferring that the prompts in the Structured Reading Framework promoted this relationship.

Relationship between the Components of the Summary Writing task Including Total Summary Writing Score

When compared to the control group, the significant correlations among the components scores of the Summary Writing task tended to be higher in the treatment group. In particular, the Audience (ADSW) component score of the Summary Writing task in the treatment group was strongly correlated with total Summary Writing score, and higher than in the control group. In this study, students were asked to write for a younger audience. The Audience component score measured whether the students' writing was appropriate for a younger audience. Students who appropriately explained to their audience developed better conceptual understanding in the Summary Writing task, which, in turn, appeared to be promoted by using the Structure Reading Framework.

Taken as a whole, Figure 3 is a diagram illustrating distinguishing differences of the correlation results on a comparison of the treatment and control groups. This diagram provides the framework for the discussion in the following section.

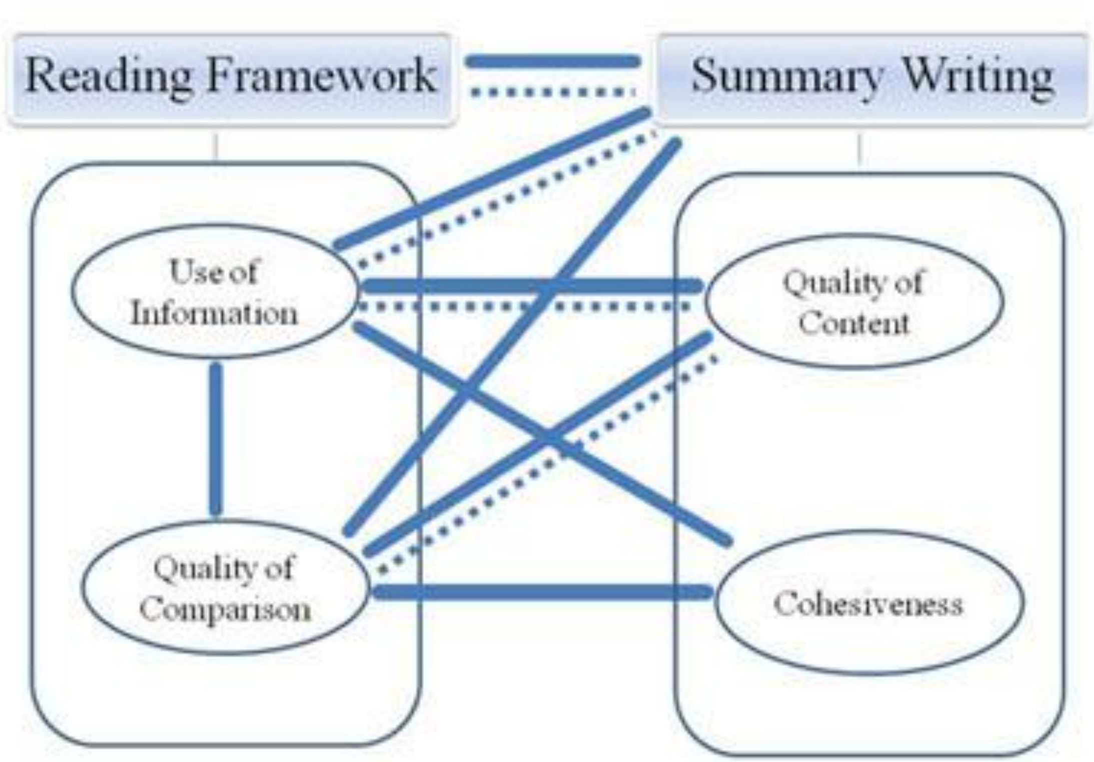

Figure 3. A Diagram of Illustrating Distinguishing Differences of the Partial Correlation Results by Group

Note: A solid line: the strong correlations for treatment group, A dotted line: the weak correlations for control group.

Overarching Key Ideas

Consideration of the overall research results suggests some key ideas that emerged from this study. Chapter II offered cognitive models of writing to describe the cognition associated with writing-to-learn activities, such as the SWH template and the Summary Writing task. It is speculated that the impact of the Structured Reading Framework on the relationships among the components of the Reading Framework and Summary Writing may be explained by using Galblraith's knowledge constitutive models.

The Reading Framework utilized during the reading phase within the SWH approach is intended to provide students with opportunities to make the connection between their previous ideas and science ideas and to promote a self-negotiation process. In this study, the Structured Reading Framework was constructed by the researcher for students to use. This Structured Reading Framework was based on two critical task stages, while the original Reading Framework has a non-structured format. The first stage centers on a more structured approach to recording information from various sources. The second stage requires students to compare their recorded information to their prior understanding and to claims and evidence that they previously generated. In terms of cognitive demand of these two tasks in the Structured Reading Framework, the first stage is more of a knowledge-telling event while the second stage is more of a knowledge constitutive event. The interaction between these two task stages are related to the dispositional knowledge (content knowledge) side of Galbraith's knowledge constitutive model. The key to expand the dispositional network appears to be in the second stage, the comparison aspect. It appears that these tasks provide students with greater opportunities for knowledge construction by building a wider range of dispositions to be activated and, hence, enabling a stronger conceptual knowledge base to develop.

The function of the Structure Reading Framework is to help students build better acceptable science knowledge through the expansion of their dispositional network. It is believed that the second stage of comparison is critical to increase one's dispositional network. Results show that the correlation between Use of Information and the Quality of Comparison components was significantly strong in the treatment group, but no correlation existed in the control group. That is, in the treatment group, the better the students gathered information, the better they were in their completing the comparison portion. It appears that this stage provides students with the opportunity to analyze and synthesize their ideas generated previously and new science ideas gained from information gathering. This leads to not only advancing their dispositional knowledge (content knowledge) network, but also strengthening it.

A strong relationship between the information gathered by students and their comparison of this information appears to build a strong foundation for the Summary Writing task activity. Results of this study indicate that in the treatment group, the Quality of Comparison component of the Reading Framework significantly correlated with the total Summary Writing score and Summary Writing components related to rhetorical knowledge. In the control group, these correlations were not significant. Since the total Summary Writing score includes both content and rhetorical knowledge components, this result appears to suggest if students compare well, their writing will be stronger. Stated differently, given that the total Summary Writing score reflects both content (i.e., Quality of Content) and rhetorical elements (i.e., Number of Modes, Cohesiveness, Accuracy, Audience) of knowledge construction, this result suggests that if students have a strong dispositional network, their writing is strengthened with the inclusion of both content and rhetorical elements. In addition, the comparison prompt in the Structured Reading Framework appeared to promote this relationship because this relationship did not exist or was weaker with students in the control group.

Taken together, the Structured Reading Framework appears to impact the development of conceptual understanding in the Summary Writing task by providing a scaffold to assist students' knowledge construction.

Implications

The results of this study provided several implications for both researchers and teachers.

Implications for Researchers

Acknowledging that the results from this study are limited in applicability because of the non-random selection, not large enough sample sizes, and unique classroom context, the results are useful in providing additional information to a developing body research with the writing-to-learn activity based argument based inquiry approach. Several implications arise from this study are discussed as a way to encourage further research.

This study was conducted using student writings from sixth and seventh grade students in the U.S. Further research should be conducted across different grade levels, such as the elementary and high school to investigate the impact of the Structured Reading Framework within the SWH approach at a broader level and help researchers understand the progression of students' thinking. In addition, a longitudinal examination would lead to more convincing conclusions.

This study was conducted within the context of the SWH approach. Further research employing a control group that does not use the SWH template will provide more evidence that the SWH template embedding Structured Reading Framework is effective in helping students learn argument.

The SWH approach consists of seven phases. As the last phase of the SWH template, the reflection section builds on and follows the reading activity to provide writing experience that requires students to examine if and how their idea have changed though the SWH. Further research needs to examine the direct and indirect effects of the Reading Framework on students' performance with sophisticated modeling and method of analysis techniques.

This study emerged from a pilot study from Korea. Further research is needed to be examining how different cultural, ethnical, and social-economical settings impact on the use of the Structured Reading Framework. Given that the same benefits are realized, this research would illuminate the value of using the Structured Reading Framework within the SWH approach

Using the student template of the SWH approach involves the use of appropriate pedagogy. Implementation of the SWH approach is guided by a template for teachers; hence, this may influence how students develop conceptual understanding (Akkus, Gunel, & Hand, 2007). In this study, there were two participating teachers from different grade levels. Classroom observations by the researcher indicated that the teachers' level of implementation appeared to be different. In particular, the teacher's role is critical for students to determine credible and reliable sources during the reading phase of the SWH approach. In this regard, how the teacher's level of implementation impacts students' learning outcome should be further investigated.

Implications for Teachers

For teachers, the main implication is the realization of the importance of the writing activity scaffolding the reading to communicate with other scientific information and promoting knowledge construction. Students need to practice synthesize and analyze scientific ideas in order to communicate in an accepted scientific manner as a fundamental part of doing inquiry. Thus, science teachers should provide students with a scaffold which guides students in the process of communication with scientific information and constructing knowledge in logical ways. The results of this study indicate that the scaffolded written framework enables students to have more information, make better comparisons, and then use information better. Therefore, we need to help teachers understand both what the scaffold is and how to implement scaffold.

The result of this study suggest that if students use more credible information, and more connected the big idea, they provide better science content knowledge in their summary writing task. Thus, science teachers should encourage students to use more credible sources and work with students to use the reliable sources to be connected the big idea. Further, science teacher need time to emphasize using credible sources of information to better set up comparison and summary writing.

Limitations

There are some limitations that arose in the study. The first limitation is a pedagogical issue. Two teachers participated in this study may be different in terms of the level of implementation of SWH approach, which may have influenced the students' learning. Since both teachers had no previous experience with the SWH approach, they may have struggled with teaching SWH. To resolve this pedagogical issue, the researcher observed their classrooms regularly, had discussions with them, and provided them with continual feedback. It was important to maintain prolonged interaction between the participating teachers and the researcher because this study had to be conducted within the context of the SWH approach. However, this prolonged interaction may have influenced the results. In addition, the participating teachers were given guidance in designing and implementing SWH approach. Yet, their teaching practice may have differed due to differences in the classroom learning environment, management type, experiences, and beliefs. Ultimately, they had the authority to decide how daily lessons in their own classrooms progressed.

The researcher admits that there was an issue associated with the scoring matrix and the analytical framework utilized in this study. These were developed by the researcher through analysis of student writing samples from a pilot study conducted in Korea and another separate project conducted in the U.S. The refinement of this tool is ongoing. The scale range of scoring matrix might not be enough to be sensible measure.

However, this information provides valuable input on ways to develop a more inclusive assessment instrument.

The small sample size of this study does not allow for generalizable conclusions. In addition, there were issues related to the students' writing samples, which were the main data sources in this study. Initially, a total of 170 students volunteered to provide their writing samples, but the number of writing samples collected within each unit by class period, unit, and grade level varied because of factors related to attendance and failure to complete the activities. In total, 896 students' writing samples were collected and scored. However, to maintain uniformity and consistency, only 588 writing samples were included in the statistical analysis. For this reason, although all students' writing samples that were collected were scored, not all were included in the statistic analysis. The final sample used may have impacted the results.

Although there was an additional rater to calculate the inter-reliability, the lead researcher of this study may have been biased in scoring the students' writing samples.

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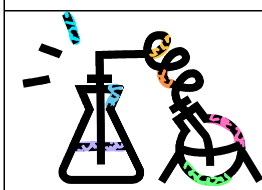
APPENDIX A

THE SWH STUDENT TEMPLATE

The SWH student template for control group

<table>
<tr><td> My Question is</td><td>My beginning understanding is:</td></tr>
<tr><td colspan="2"> This is the test(s) I did to answer my question:</td></tr>
<tr><td colspan="2">This is what I found when I tested:</td></tr>
</table>

My claim is:
My evidence is:

 How do my ideas compare with others?

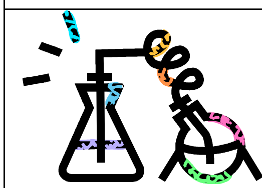
**Notes from my classmates……….*

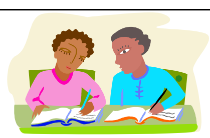
 ***** *Notes from outside experts (informational text, internet, encyclopedia, etc.)*

Reflections:

My ideas have changed because….	My ideas haven't changed because……

The SWH student template for treatment group

 My Question is	My beginning understanding is:
 This is the test(s) I did to answer my question:	
This is what I found when I tested:	

My claim is:
My evidence is:
 How do my ideas compare with others? **Notes from my classmates……….*

< Reading framework>

Notes from outside experts: (informational text, internet, encyclopedia, etc.)

Source 1: Author:_______________ Title: _________________	Source 2: Author:_________________ Title: __________________	Source 3: Author: __________________ Title: ___________________
Information: (What I knew from the source?)	Information:	Information:
How do the information from source compare/contrast to my claim/evidence?		

Reflections:

My ideas have changed because….	My ideas haven’t changed because……

APPENDIX B

PARTIAL CORRELATION RESULT FOR OVERALL GROUP

Table B-1. Partial Correlations among the Components of the Reading Framework and the Summary Writing Task for Overall Group

	Components of the Reading Framework				Components of the Summary Writing Task				
	UI	QC	NM	TOTAL RF	QCSW	NMSW	CSSW	ACSW	ADSW
QC	.536**								
NM	.731**	.302**							
TOTAL RF	.916**	.737**	.825**						
QCSW	.436**	.305**	.388**	.456**					
NMSW	.311**	.206**	.362**	.356**	521**				
CSSW	.335**	.358**	.383**	.434**	.528**	.708**			
ACSW	.321**	.232**	.331**	.357**	.484**	.757**	.714**		
ADSW	.377**	.304**	.337**	.411**	.715**	.319**	.485**	.333**	
TOTAL SW	.442**	.349**	.448**	.501**	.806**	.824**	.856**	.822**	.707**

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

Note: The partial correlation results did not change in any important way when the analysis with the raw score composites was conducted.